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Assessment of the degree of carbon leakage in light of an international agreement on climate change

A report for the Department of Energy and Climate Change

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Executive Summary

This Executive Summary first sets out the key findings, and then discusses the background for our research, the methodology we adopted and some of the results in more detail.

Key Findings The key findings of the research are as follows:

- For each of the sectors selected as part of this analysis (see Table ES.1 and ES.2[1]), and with caveats, we found that only when both a sector's trade intensity and carbon cost are moderate to high, is a sector exposed to a large risk of carbon leakage. The largest price elasticities (which capture demand responses and are a key determinant of overall levels of leakage), are recorded in sectors producing more homogeneous (less differentiated) products.

- We believe that the European Commission's (The Commission) criteria (see Box ES.1) are fairly robust for assessing carbon leakage, but that the thresholds chosen may select too many sectors and do not place enough emphasis on sectors which really are at risk of carbon leakage. We find that sectors with low carbon cost and varying levels of trade intensity are at equally low risk of carbon leakage.

- There are a number of additional criteria referred to in the literature, many of which are suitable indicators of the factors that contribute to carbon leakage, including profit margins, transport costs and demand growth. However, because of the limitations of data availability and the subjective problem of applying weighting to criteria it was not possible to use these additional criteria to compare and assess all sectors potentially at risk of carbon leakage.

- Broadly, our qualitative research agrees with our quantitative findings. This is most true for sectors found to be highly exposed to production losses and those sectors almost entirely unexposed to production losses as a result of European Union (EU) carbon cost differentials. However, the qualitative assessment is able to consider factors outside the quantitative framework, including supply chain cost impacts, the co-location of production and the impact of other regulations. As such, the qualitative findings sometimes appear to be at odds with the findings of the quantitative assessment.

- The allocation of free allowances (if, as assumed in this study, they reduce the pass through rates of carbon costs) is more effective in reducing carbon leakage than border adjustment mechanisms (BAMs) applied to imports into the EU, for the sectors analysed. This result occurs because our findings suggest that for these sectors, more leakage occurs through the loss of export markets than through import substitution[2].

- Table ES.1 shows the change in EU production of the sectors assessed, for four scenarios and sensitivities: the first shows an EU target of 20% GHG emissions

[1] Ten sectors were selected by DECC and this is discussed in full in Chapter 3. Four additional sectors were included as we were able to build on previous analysis.

[2] Our modelled BAM policy was import, rather than export, orientated

reductions in 2020 relative to 1990 levels, with no action from other countries (S1); the second shows an EU 20% target with other countries at the lower end of their Copenhagen Accord offers (S2) (where they have submitted a range); the third shows an increase to a 30% EU target with other countries at the lower end of their Copenhagen Accord offers (S3); and the fourth shows the same EU 30% scenario but with EU sectors receiving free allowances covering 80% of their emissions levels (S3b).

- Table ES.1 shows the production loss for each of the 14 sectors assessed. We recognise that production loss is only a proxy indicator for leakage (as it also includes the impact of domestic demand) and that production shift, and indeed the shift in emissions, would be a more suitable indicator. However, it is not possible to accurately quantify production shifts without modelling the response outside of the EU with regard to non-EU domestic production substitution for EU exports. Moreover, we believe that production loss gives a robust indication of the possible scale of leakage and is an adequate representation of industry concerns. The sectors most at risk of a loss of EU production (our proxy indicator for carbon leakage): Manufacture of Lime, Manufacture of Basic Iron and Steel and of Ferro-alloys, and Manufacture of Ceramic Tiles and Flags. The cost impact of Manufacture of Ceramic Tiles and Flags is unknown but has been estimated by the Commission to be between 5 and 30%, for the purposes of identifying the worst-case impact we have modelled at the upper bound of the cost estimate range.

- The difference between the Reference scenario and the Copenhagen Low scenario is small, suggesting that the offers put forward in the Copenhagen Accord have

TABLE ES.1: PRODUCTION IMPACTS

	Change in EU production (%)				Commission's Criteria	
	S1	S2	S3	S3b	Cost (%)	Trade (%)
Manufacture of paper and paperboard	-0.6	-0.6	-0.8	-0.5	10.2	25.7
Manufacture of other inorganic basic chemicals	-0.9	-0.9	-1.2	-0.8	<5.0	40.6
Manufacture of plastics in primary forms	0.0	0.1	0.1	0.1	2.2	29.5
Manufacture of glues and gelatines	0.0	0.0	0.0	0.0	0.9	25.9
Manufacture of flat glass	-1.2	-1.2	-1.6	-0.8	7.1	21.0
Manufacture of glass fibres	-0.2	-0.1	-0.2	-0.2	3.4	23.5
Manufacture of ceramic tiles and flags	-15.1	-14.9	-20.0	-6.8	>5,<30	28.6
Manufacture of bricks, tiles and construction products, in baked clay	-0.1	-0.1	-0.1	-0.1	5.1	2.7
Manufacture of lime	-12.1	-12.1	-16.1	-5.5	65.2	2.6
Manufacture of plaster products for construction purposes	-0.8	-0.7	-1.0	-0.5	1.1	5.7
Manufacture of basic iron and steel and of ferro-alloys	-11.6	-11.5	-15.4	-8.5	10.6	32.3
Casting of steel	0.0	0.0	0.0	0.0	2.2	na
Manufacture of agricultural tractors	-0.2	-0.2	-0.3	-0.1	>5,<30	31.1
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.60	28.9

Note(s): S1 is the Reference Scenario, S2 is the Copenhagen Low Scenario, S3 is the Copenhagen Low, EU Stretch Copenhagen Low Scenario, and S3b is the EU Stretch Copenhagen Low Scenario with 80 % free allowances.
Source(s) : Cambridge Econometrics.

negligible impact, in terms of offsetting the production loss, for the sectors assessed. Further, the shift from a 20% EU GHG reduction target to a 30% EU GHG reduction target only has a very small impact on all but the three sectors already identified as being at risk. For the sectors facing a substantial production loss the additional impact of meeting the 30% EU target is modest.

- Of most interest, from a policy perspective at least, is the substantial impact of 80% free allowances in reducing production losses (assuming that these free allowances reduce the rate at which firms pass through their increased costs to their prices). This is particularly true for the sectors most at risk of production losses which see production losses reduced by 40-60%. Of the three sectors the impact of 80% free allowances is smallest in Manufacture of Basic Iron and Steel of Ferro-alloys because free allowances do nothing to offset the cost of the increased electricity costs.

- Manufacture of Plastics in Primary Forms in the EU actually increases by a very small amount (0.1%) in the Copenhagen Low and EU Stretch scenarios[3]. This result is driven by the cross price elasticity of demand for domestic production to import prices. The impact is small in size because the cost impact is so small to non-EU producers. The own price elasticity of demand was zero, as discussed in Chapter 4, this is possibly due to the relative homogeneity of the product as there might be insufficient variation between domestic (and export) prices, and import prices in the historical period as prices have been driven by the cost of the main feedstock; oil. This has potentially introduced a downward bias in the results for this sector.

Background and Objectives

The research was undertaken in the following context:

- The Department of Energy and Climate Change (DECC) commissioned Cambridge Econometrics (CE), Climate Strategies (CS) and Entec to assess the nature and degree of carbon leakage, for specific sectors, in light of an international agreement on climate change.

The analysis builds on the research undertaken by the European Commission

- The Commission had previously identified 164 sectors, defined at the NACE[4] four digit-level, at risk from carbon leakage. The selection was based upon two criteria calculated for each sector: its trade intensity (how much trade into and out of the European Union) and the increases in total input costs expected from the impact of a carbon price.

- As part of ongoing international agreements on climate change, the EU has offered to set a target of up to 30% reduction of greenhouse gas emissions (GHGs) by 2020 contingent on comparable international effort: the current target is 20%. This study seeks to report the impact on selected sectors of extending this target on carbon leakage.

[3] It is the case that (even though in all scenarios the carbon price (and therefore rise in production cost) in the EU is greater than the price in the rest of the world) because of the high price elasticity of imports (i.e. the decrease in imports due to the rise in import prices as a result of the Copenhagen Accord pledges), domestic production increases so as to more than offset the decrease in domestic production resulting from reduced domestic demand and reduced export demand

[4] NACE is the statistical classification of economic activities in the European Community

Defining and measuring carbon leakage

- For the purposes of this study, we attempt to indicate carbon leakage as a loss in EU production. However, we would ideally measure the shift in production from EU regions to non-EU-regions resulting from the cost pressure as a result of the extra cost of reducing CO_2 emissions faced by EU producers under the Emissions Trading System (EU ETS), but it is not easily possible to do this without a full quantitative assessment of the sectors outside the EU. The loss in production is derived from the loss in domestic demand and export demand, we also report the import substitution recorded from our quantitative analysis.

- Leakage might occur through international firms gaining market share (both within the EU and globally) leading to shifts in production, or through the relocation of EU firms to outside the EU. This study focuses on carbon leakage resulting from the cost impact of the EU ETS including the indirect impact of higher electricity prices. While we recognise that additional costs from other climate policy initiatives are an important issue, it is not within our remit and therefore not accounted for in this study and we recommend that these additional impacts are assessed in further pieces of research.

Objectives

- The study has two main sub-objectives each undertaken in a separate phase:
  - Phase 1: To assess whether there are criteria additional to those currently used by The Commission which could refine the identification of sectors at risk from carbon leakage as well as assess the validity of The Commission's own criteria and thresholds
  - Phase 2: To assess the degree of leakage, for selected sectors, in light of various carbon mitigation scenarios and policy interventions and in doing so provide a second assessment on The Commission's criteria

Phase 1

This Phase of the study attempted to find quantitative criteria which could be used in conjunction with the two existing quantitative criteria that The Commission employs to judge the risk of carbon leakage (see Box ES.1), in order to determine which sectors might be deemed at greatest risk of leakage.

BOX ES.1: THE COMMISSION'S CRITERIA TO IDENTIFY SECTORS AT RISK OF CARBON LEAKAGE

A sector meeting any one of the following thresholds in The Commission's assessment is deemed to be at risk of leakage:

- increase in production costs > 5% of GVA, and extra-EU trade intensity > 10%;
- increase in production costs > 30% of GVA
- extra-EU trade intensity > 30%

These factors are calculated at a €30/t carbon price and assume no corresponding carbon control regime change in the Rest of World.

Source(s) : Entec and European Commission.

- In doing this we considered commonly used concepts from the carbon analysis literature as follows:
  - markets (pass through ability)
  - cost structures (cost impact)
  - investment in research and development (abatement potential)
  - legal and regulatory constraints
- Other approaches exist which, instead of drawing primarily on micro-economics, emphasise political factors or international trade, or better represent the types of leakage which occur across sectors rather than within one, but these did not have the same generality and were not used in this study.
- After selection of the framework for categorising effects, a comprehensive survey of the leakage literature was undertaken. The aim was to identify terms used in the literature and group them under the headings above. The effect was to ignore relationships and causality specifically proposed by authors and to extract only the concepts they used.
- The list of criteria was filtered based on a consideration of data availability and prioritised according to a subjective degree of relevance to this study (see Tables 3.4a-d in the full report).
- The selection of criteria under "Markets" included:
  - The Commission's trade intensity criteria
  - market segmentation and industry structure
  - demand growth and market characteristics
- The selection under "Cost Structures" included:
  - the European Commission cost criteria
  - international transport costs
  - profit margins
  - sunk costs
- Market segmentation and industry structure was most often quoted as a causal factor in the literature, but was most difficult to characterise and quantify. Sunk costs were similarly understood as important but difficult to estimate. With these removed, the criteria taken forward into a quantitative assessment included The Commission's two criteria plus profit margins, transport costs, and demand growth.
- Criteria under "Investment in Research and Development" and "Legal and Regulatory Constraints" were not taken forward predominantly due to a lack of standardisation in the variables chosen to represent them in the literature and a lack of data allowing comparability between sectors.
- As well as identifying relevant criteria, businesses need to make decisions regarding the relative importance of factors (criteria) to an overall decision. The Commission's criteria system includes an implicit weighting. For example, a sector is deemed at risk of leakage when cost is greater than 30% implicitly weighting the cost criteria at 100% and the trade intensity at 0%. With the inclusion of additional criteria comes the need for a more refined weighting system. Such systems are inherently subjective and the report includes the results

of a range of weightings. Until these can be tested based on observed leakage, only subjective values can be chosen.

- In practice, it proved difficult to apply the criteria in a robust way. Even if all criteria had been accurately quantifiable, there remains a need to weight the different criteria to produce an overall score, and this weighting system is inherently subjective until it can be tested through measurements of actual leakage.

- As regards the criteria themselves, the main difficulty was the lack of a suitable proxy for the impact of industry structure or other criteria of cost-pass through ability as this provides a key mitigating measure as it relates to how a sector can distribute the effects of carbon policies more widely within the economy.

- The study therefore does not firmly recommend the use of additional quantitative criteria in addition to those already employed by The Commission to determine the risk of leakage.

Selection of criteria for Phase 2 of the study

- DECC decided to select for further analysis in Phase 2 a set of ten sectors which sat close to the threshold levels of production cost increase and trade intensity that are employed by The Commission to determine which sectors are at risk of leakage. The aim was to stress-test the effectiveness of these thresholds, by choosing some sectors either side of the thresholds and using econometric analysis to determine whether they are indeed effective indicators of the degree of leakage.

- The ten sectors are identified in Table ES.2 (the full table in the report, Table 3.6 identifies why a particular sector was selected). Four additional sectors, also shown in Table ES.2, were modelled as the elasticities had been calculated for a separate study for DG Enterprise: Manufacture of Glues and Gelatines, Manufacture of Basic Iron and Steel, Manufacture of Paper and Paperboard, and Manufacture of Ceramic Tiles and Flags.

TABLE ES.2: DECC SELECTION OF SECTORS

NACE	Sector	Cost/GVA (%)	Trade Intensity (%)
2413	Manufacture of other inorganic basic chemicals	11.9	31.7
2611	Manufacture of Flat Glass	8.0	21.0
2416	Manufacture of plastics in primary forms	3.0	27.1
2614	Manufacture of glass fibres	3.6	23.4
2640	Manufacture of bricks, tiles and construction products in baked clay	9.8	2.7
2652	Manufacture of Lime	65.2	2.6
2662	Manufacture of plaster products for construction purposes	3.2	5.7
2752	Casting of steel	2.0	
2931	Manufacture of agricultural tractors	>5, <30	31.1
3410	Manufacture of motor vehicles	0.5	28.9
DG Enterprise Sectors			
2112	Manufacture of Paper and Paperboard	10.2	25.7
2462	Manufacture of Glues and Gelatines	0.9	25.9
2630	Manufacture of Ceramic Tiles and Flags	>5, <30	28.6
2710	Manufacture of Basic Iron and Steel	10.6	32.2

Note(s) : Cost/GVA is the sum of the direct and indirect carbon cost as a percentage of GVA
Trade intensity is defined as the ratio between total of value of exports to non-EU + value of imports from non-EU and the total market size for the Community (annual turnover plus total imports)
Source(s) : European Commission.

- It is noted that even the assessment of sectors defined at the NACE four-digit level of disaggregation also represents a potential selection bias. For example, a sector such as Glass Fibres is perceived to not be at risk of carbon leakage, whereas the sub-sector of Glass Fibres, Continuous Filament Glass Fibres is considerably more carbon intensive than its parent sector as a percentage of GVA, and has been found to be at risk of carbon leakage by The Commission.

- Chart ES.1 shows the sectors against The Commission’s criteria thresholds: all the sectors to the left and below the threshold line are not at risk of carbon leakage according to The Commission’s criteria, whereas all sectors above and to the right of the line are, by default, assessed to be at risk of carbon leakage according to The Commission’s criteria. The chart highlights the relative arbitrariness by which a sector might find itself just either side of one or more of the criteria thresholds.

- On Chart ES.1, the sectors shown in green are not at risk of carbon leakage according to The Commission’s criteria, from left to right they are: Casting of Steel, Manufacture of Bricks, Tiles and Construction Products including Baked Clay, Manufacture of Plaster Products for Construction Purposes, Manufacture of

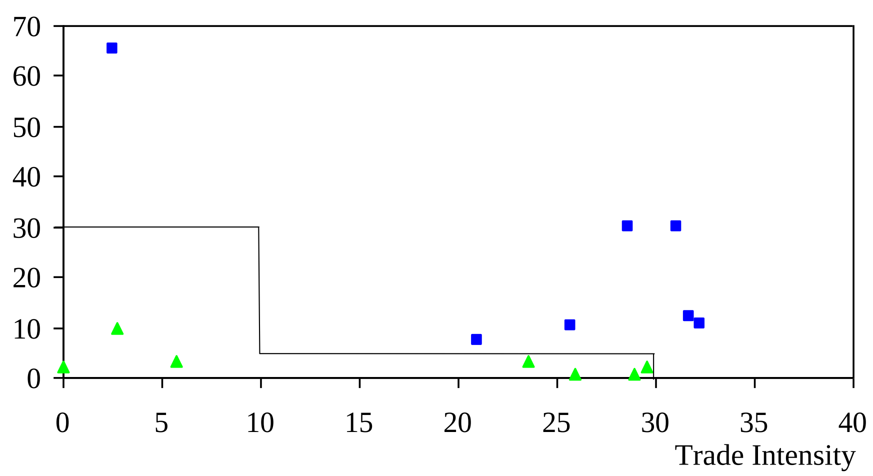
Glass Fibres, Manufacture of Glues and Gelatines[5], Manufacture of Plastics in Primary Forms[6], and Manufacture of Motor Vehicles.

- The sectors in blue are deemed to be at risk from carbon leakage according to the Commission's criteria, from left to right they are: Manufacture of Lime, Manufacture of Flat Glass, Manufacture of Paper and Paperboard, Manufacture of Ceramic Tiles and Flags, Manufacture of Agricultural Tractors, Manufacture of Inorganic Other Basic Chemicals and Manufacture of Iron and Steel and Ferro Alloys.

- As part of the review, we undertook an assessment of the sectors selected by DECC, to review qualitatively the sector against the identified criteria. We also reviewed two extra sectors (Copper Production and Manufacture of Pulp) in order to populate the list of criteria (see Chapter 2 and 3), as this was undertaken before DECC's selection of the sectors for analysis. By understanding more of each sector's characteristics, it was possible to anticipate potential sources of leakage within the production process. The degree of detail in the qualitative studies was limited by what information was available in the public domain, for some sectors this was very little. The sector studies assisted with developing working hypotheses as to how they might be affected by increased carbon pricing which would be assessed quantitatively in Phase II.

- The qualitative assessment gave mixed results for many sectors, as for some assessment criteria there was an indication of a risk of leakage whilst for others there was not and so the net result and overall risk of leakage was uncertain. This

CHART ES.1: SELECTED SECTORS MAPPED AGAINST THE EC THRESHOLD CRITERIA



Note(s) : Blue squares represent sectors at risk of carbon leakage following the EC assessment criteria, while green triangles are sectors not at risk.

Source(s) : EC, Cambridge Econometrics.

[5] The Commission found the sub-sector Gelatines to be at risk of carbon leakage.

[6] The Commission's qualitative assessment found Manufacture of Plastics in Primary Forms to be at risk of carbon leakage.

was particularly true for those sectors that were close to (both above and below) The Commission's threshold e.g. Glass fibres and Flat Glass. It was particularly difficult to detect a discernable difference in the risk of leakage for sectors that had low cost but were close to the 30% threshold for The Commission's trade criterion.

Phase 2 The purpose of Phase 2 was to quantitatively assess the degree of the risk of leakage for the selected sectors. The main findings of Phase 2 and the methodology we employed are as follows:

- We sought to build a framework for assessing the degree to which a sector is at risk of carbon leakage. The purpose of designing a transparent but flexible framework is to allow the tool to be used on other sectors, to allow the tool to be developed further, and to allow sectors to test their own assumptions regarding price elasticities, carbon costs and the degree of cost-price pass-through.

- The major task of this phase was to estimate Armington, or trade, price elasticities. To do this we followed the method developed as part of research for The Commission (DG Enterprise)[7]. This method was assessed by The Commission to be robust and the method most suited to the data available. We employed a panel data econometric method to estimate trade elasticities for domestic demand, import demand and export demand.

- Although the method is assessed to be robust, there are a number of factors which need to be considered as caveats to the estimates we have derived. For some sectors the Eurostat data are lacking for several key variables and this might impact on the results.

- Any econometric method is subject to the criticism that the elasticities obtained might not be suitable for future policy assessment if the policy implies a substantial shift or causes a structural break. For the sectors we assessed, this is most true of Manufacturing of Lime because the cost is such a large proportion of GVA. For such a sector we recommend further in-depth case study analysis, building on the quantitative assessment provided here, other qualitative factors and considerable industry input.

- The elasticities were calculated for the 10 sectors selected by DECC and we also made use of elasticities calculated for 4 additional sectors as part of a study for DG Enterprise. The elasticities are shown in Table 4.2 in the main report.

- The elasticities suggest that there are significant relationships between domestic demand and domestic prices; import demand and import prices; and export demand and export prices for most sectors. However, we found little evidence for cross price elasticities, for example where domestic price changes might lead to import substitution. This is an interesting result and can be caused by two factors, it is possibly the result of sufficient homogeneity in the production process that domestic and import prices have moved together over the historical period, or there is sufficient product heterogeneity that imports are not suitable substitutes.

[7] For more information see: http://ec.europa.eu/enterprise/policies/sustainable-business/climate-change/energy-intensive-industries/carbon-leakage/index_en.htm

Unfortunately the policy conclusion of this finding is ambiguous and more research is needed.

- It is our view that the elasticities are only the first step in an ongoing process of developing the evidence base for assessing the degree to which sectors are at risk of carbon leakage, and we recognise that these elasticities might be in direct contradiction of industry expectations. We have therefore sought to reflect industry comments[8] throughout the reporting of our results in this study.

- We integrated the elasticities into a model assessment framework, to account for trading partner costs, cost-pass through assumptions, carbon intensity of electricity of trading partners, trade weights, carbon cost assumptions and policy assumptions (see Chapter 5 for details).

- In total we modelled four scenarios to reflect possible outcomes of an international agreement on climate change mitigation by 2020, they are: Reference Scenario (EU 20% GHG reduction), Copenhagen Low (EU 20% GHG reduction and low Copenhagen Accord ambition), EU stretch (EU 30% GHG reduction and low Copenhagen Accord ambition) and Copenhagen High (EU 30% GHG reduction and high Copenhagen Accord ambition). The carbon costs in the scenarios are designed to reflect our assessment of the pledges under the Copenhagen Accord, for the relevant trading partners (see Table 6.2 for details). Our appraisal, with input from DECC, of the Copenhagen Accord suggests that moderate carbon cost differentials will exist between the EU and its major trading partners in all of our four future scenarios. The results were not substantially different across scenarios.

- The results of the framework, overall, suggest that for the sectors modelled there will be only modest leakage as a result of the carbon cost differential. However, there are considerable differences between sectors, and caveats which are more applicable to some sectors than others, this is discussed in Chapter 7 and summarised for each sector later in the Executive Summary.

- Generally, our quantitative assessment found more evidence for carbon leakage in sectors which faced both high cost impacts and were heavily exposed to extra-EU trade. Sectors which had low cost and high trade exposure were not found to be at much risk of carbon leakage. Perhaps more importantly, sectors with similarly low cost which had varying trade intensities were found to be at equally low risk of carbon leakage. Manufacturing of Lime stands out as a sector exposed to high costs but low levels of trade, and in our modelling we find strong evidence of falls in domestic demand and production but only modest evidence of carbon leakage (a shift in production to outside of the EU). However, there are a number of other factors for this sector which need to be considered as the substantial cost impact (65.2%), creates a cost differential which is beyond the historical data variation.

- We found more evidence for loss of export markets than import substitution, as indicated by the sector elasticities. The weak evidence for import substitution does appear to contradict our *a priori* expectations from the qualitative review for some

[8] Industry comments have been reflected in the report after inviting feedback on the report from members of the Emissions Trading Group.

sectors. One potential reason for this result might be that cost differentials between EU and non-EU producers were not as great in the historical period as they might become. This is certainly true for an industry such as Manufacturing of Lime, and to a slightly lesser extent Manufacturing of Basic Iron and Steel. The suggested loss of export markets is clearly an important feature of the results and for sectors where the export market is substantial there are clear policy implications, particularly in regard to Border Adjustment Mechanisms (BAMs).

- We modelled three policy sensitivities aimed at mitigating carbon leakage: 80% free allowances, 50% free allowances and BAMs on imports (inclusion of importers through pricing carbon at the border).

- The results of the policy modelling suggest the free allowances are more effective in preventing carbon leakage than inclusion of importers into the ETS carbon pricing system through a BAM. However, free allowances do not assist sectors with the additional cost of increasing electricity costs and so in sectors which are considered at risk and with a relatively high proportion of electricity costs, some leakage might still occur (eg Basic Iron and Steel), whereas for the purposes of our modelling indirect costs were included in the BAMs. As one of the key findings was that we find more evidence for export-led carbon leakage, BAMs on import prices, as we have modelled them, are not particularly effective. However, BAMs which are used as subsidies to export prices might be effective, but this is similar in nature to the allocation of free allowances.

Modelling caveats

- However, the model framework makes certain stylised assumptions and our indicative results need to be considered in light of these qualifications. This is discussed in the following summaries for each sector but there are also some general caveats (discussed at length in Chapter 5, Chapter 6 and each sector Appendix).

- The main shortcomings of the sector framework are that, by design and because of data limitations, the sector frameworks do not account for the potential increasing costs of other materials as a result of carbon cost increases in those sectors (the exception is the electricity sector). Also, the model, due to its comparative static framework does not account for the dynamics and the whole economy knock-on impacts. The modelling is therefore both partial and static as the disaggregated detail of the sectors necessitates. The sector framework also separates the assessment of carbon costs for the production of intermediates and their traded derivatives, which, though integrated on the same site are classified to different sectors.

Cost-price pass-through

- We have used pass-through rates based on CE's E3ME model of Europe. This means that for many sectors pass-through rate assumptions are based on historical relationships for pass-through, usually at the NACE 2 digit level. By design the model is flexible to assess other pass-through rate assumptions, which might arise through industry consultation. Perhaps more importantly, because this is a partial static modelling approach we are only concerned with the demand loss as a result of the expected price changes. However, we recognise that if costs are not passed on through prices then they must be absorbed by reduced profits, this may have implications for long term investment and competitiveness of the sectors.

- Plainly, it is difficult to make any firm conclusion regarding the impact of pass-through rates on leakage. If a firm passes costs on this might be because it can, but it might be because it simply cannot absorb the cost. In either case it will face a demand reaction. If a firm chooses not to pass costs on and absorb them in the form of diminished profit, this might reduce long term inward investment into production capacity in regions with costly carbon prices.

- In addition, this study makes the somewhat simplified assumption that free allowances serve to reduce pass through rates. This contradicts the principle of opportunity cost pricing whereby even free EU allowances represent an increased production cost to firms, who would otherwise sell them if they did not use them for production. However, it does allow an analysis of the extent to which leakage would be reduced if firms in highly competitive markets were able to prevent cost pass through as a result of free allowance allocation,

Sector summaries

We investigated each of the 14 sectors in isolation, because of this the following discussion considers the results of our approach (qualitative assessments from Phase I and quantitative analysis from Phase II) against The Commission's criteria by sector (revision 1.1 NACE codes are given in parenthesise). The qualitative assessment was intended to provide background and context to the quantitative assessment. The results of these two approaches were sometimes at variance, partly because the qualitative assessment was unable to give an accurate assessment of the scale of the risk of leakage for each subsector, only the likely sources and drivers. In the following sector summaries changes in production are given for the EU Stretch Copenhagen Low scenario.

Manufacture of Flat Glass

- Manufacture of Flat Glass (2611): Based on The Commission's criteria, this sector faces costs of 8.0% of GVA and trade intensity of 21.0% relative to output, and is therefore determined to be at risk of carbon leakage according to The Commission's criteria. Our qualitative analysis suggests that the sector is at modest risk of carbon leakage, predominantly driven by its lumpy investment cycle and countered by large transport costs which might reduce the risk of leakage. The sector is energy and emissions intensive and production capacity is growing in countries close to the European border countries. In recent years, the EU's trade surplus has become a deficit, implying increased competition from overseas in spite of the high transport cost. The quantitative modelling analysis, by contrast, suggests that the sector will only see a reduction in EU production of 1.6% in the EU Stretch Copenhagen Low scenario. Partly this happens because cost pass-through is only moderate, but even if this is the case, this must mean that the long term profitability of the industry is open to some risk, potentially reducing future investment.

Manufacture of Plastics in Primary Forms

- Manufacture of Plastics in Primary Forms (2416): Based on The Commission's criteria, this sector faces costs of 3.0% of GVA and trade intensity of 27.1% and is therefore determined not to be at risk of carbon leakage according to The Commission's criteria but was added to the list following The Commission's qualitative assessment. Our qualitative analysis also identifies a number of potential risks, suggesting that EU cost differentials have already diminished profitability, and much of the abatement potential has already been realised.

Although they are differentiated in terms of quality, plastics are largely homogenous goods and so compete on price. Although Europe continues to enjoy a large trade surplus in this subsector, there is increasing competition from extra-EU countries which have lower production costs, partly due to subsidised inputs. However, the quantitative analysis suggests that there will not be a production shift, simply because of the small cost impact, however this analysis ignores a number of factors. First, profit margins might be reduced below sustainable levels (as only some of the cost can be passed on) and second, there are complexities in the production process which mean that industries will often co-locate; on the one hand this might reduce carbon leakage (as firms retain existing connections) or exacerbate it (as the whole interrelated supply chain shifts outside the EU). In addition, it is possible that due to the relative homogeneity of the product there might be insufficient variation between domestic (and export) prices, and import prices in the historical period, potentially introducing a downward bias in the results (see Chapter 4 and Chapter 7).

Casting of Steel

- Casting of Steel (2752): Based on The Commission’s criteria, this sector faces costs of 2.0% and has unspecified (or unknown) trade intensity and is determined not to be at risk of carbon leakage. While the qualitative analysis of this sector suggests it might be at risk due to its integration with the wider steel manufacturing process and the likely risk of co-location should other steel subsectors relocate, in the quantitative analysis we find the sector to be unexposed to a production shift (0%), given the small cost impact and demand elasticities.

Manufacture of Glass Fibres

- Manufacture of Glass Fibres (2614): Based on The Commission’s criteria, this sector faces costs of 3.6% of GVA and trade intensity of 23.4% and is therefore determined not to be at risk of carbon leakage according to The Commission’s criteria. The quantitative analysis backs this assessment, with very small shifts in production (-0.2%) recorded. However, the NACE 4 digit sector analysis hides the fact that the NACE 6 subsector Continuous Filament Glass Fibres might be at risk, and merits further investigation (as recognised by The Commission’s own analysis). Our qualitative research suggests that because of the sunk cost into production capital and a high degree of product differentiation this sector is also relatively unexposed to the risk of leakage.

Manufacture of Plaster Products for Construction Purposes

- Manufacture of Plaster Products for Construction Purposes (2662): Based on The Commission’s criteria, this sector faces costs of 3.2% of GVA and trade intensity of 5.7% and is therefore determined to not be at risk of carbon leakage. The quantitative analysis backs this up as the industry is driven almost entirely by demand from EU construction, it is also reasonably price insensitive, and the cost impact is small. Our quantitative analysis suggests EU production will be reduced by just 1% in the long term.

Manufacture of bricks, tiles, etc

- Manufacture of bricks, tiles and construction products incl. baked clay (2640): According to The Commission’s criteria this sector faces relatively high costs of 9.8% but is not exposed to extra-EU trade, with a trade intensity of just 2.7%. The Commission’s criteria suggest that this sector is therefore not at risk of carbon leakage. Like the Plaster Products sector, both our quantitative and qualitative research suggest that demand is predominantly driven by the construction industry and is relatively price insensitive. A number of smaller kilns in this subsector fall below the emissions threshold and aren't included in the EU ETS. These small-scale operations mean that markets are often regional, largely because of high transport costs relative to the product's value added, suggesting that the sector is probably not at great risk of carbon leakage. The quantitative assessment suggests that EU production will be reduced by just 0.1% in the long term.

Manufacture of Lime

- Manufacture of Lime (2652): Based on The Commission's criteria this sector faces severe costs 65.2% of GVA but is currently not very exposed to trade (with a trade intensity of just 2.6%). The econometric modelling suggests that the sector will lose much of its export market as a result of the cost pass-through; perhaps worse, the results suggest that a substantial amount of domestic demand could be lost. Overall, the analysis suggests that the sector might lose 16.1% of current production levels in the long term. The domestic demand might be lost through more efficient use of lime products as an intermediate input, a shift to possible substitutes or production methods which do not require lime, or because businesses using lime products are forced to reduce their own output. In our approach, we do not see any evidence for import substitution. However, the cost differential between the EU and outside the EU is far beyond what we observe in the historical data, it is possible therefore that considerable switching may occur. Also, the results only show the demand responses to prices using a cost pass-through rate of 58%, which implies that profits will have to absorb 42% of the additional cost increase. This sector certainly merits further investigation as our findings are inconclusive on the risk of carbon leakage for this sector. Moreover, our qualitative analysis supplemented by industry advice suggests that the sector cannot abate its carbon emissions easily since carbon emissions in Manufacture of Lime are predominantly process emissions, rather than energy related emissions. Energy costs are already high in this sector as a percentage of total input costs. Carbon costs are expected to be very high, and will heavily impact on the sector's profit margins.

Manufacture of Agricultural Tractors

- Manufacture of Agricultural Tractors (2931): Following The Commission's criteria this sector faces costs between 5% and 30% and has trade intensity of 31.1% it is therefore seen to be at risk of carbon leakage. We were unable to find evidence of any research undertaken on this sector with regard to carbon leakage. Our quantitative evidence for this sector suggests that it is not at risk of carbon leakage (even modelled at the 30% cost bound), as we estimate a long term fall in EU production of just 0.3%. We suggest that this result reflects considerable product differentiation between the EU and export markets. However, the data for this sector are even less comprehensive than many of the other sectors; we were even unable to find much qualitative information on this sector.

Manufacture of Motor Vehicles

- Manufacture of Motor Vehicles (3410): Based on The Commission's criteria this sector faces very low cost impacts of 0.5% of GVA and trade intensity just below The Commission's criteria (28.9%). Therefore, according to The Commission's criteria this sector is not at risk of carbon leakage. However, this highlights the arbitrariness of The Commission's carbon leakage criteria thresholds as trade intensity could easily grow beyond 30%. The manufacture of motor vehicles is an example of a complex manufacturing process; the end products are differentiated in terms of technical detail and branding and Europe is the world's largest vehicle producer. However, the manufacture of vehicle components can be outsourced to areas without carbon pricing and so the integration of this manufacturing sector with upstream subsectors such as steel needs to be considered. Our results suggest that the cost impact from electricity costs is not substantial enough, according to our modelling, to cause carbon leakage; we estimate no production loss in response to the carbon costs modelled. However, the industry is also under considerable pressure from related carbon mitigation policies, not least to reduce tailpipe emissions for new European cars, which might increase the costs of production but will be true for all cars sold in Europe. In our approach we have, by data necessity, not accounted for complex industry to industry relationships, but there is certainly a theoretical argument that if production of intermediate goods shifts outside the EU, so might the final production processes. As such we make the recommendation that a whole economy input-output dynamic modelling approach is undertaken to investigate such impacts.

Manufacture of Other Inorganic Basic Chemicals

- Manufacture of Other Inorganic Basic Chemicals (2413): According to The Commission's criteria this sector faces a relatively high cost increase at 11.9% of GVA and also has a high trade intensity of 31.7%. Following The Commission's criteria, it is therefore at risk of carbon leakage. However, we find the sector to be at low risk of carbon leakage, as demand is perhaps relatively unresponsive to price changes; we see a modest fall off in exports and a small fall off in domestic demand with no switching to imports. Overall, we estimate an EU production loss of 1.2% in the long term. However, a considerable amount of the cost is not passed on (in our modelling) and must therefore be absorbed by the sector; this is an important consideration for a sector with relatively high costs. Moreover, as discussed in the qualitative research, there are complexities which are beyond the quantitative sector data: industry consultation suggests that industrial processes and linkages between the basic chemical subsectors (e.g. products in one subsector might act as feedstocks for another) mean that industries benefit from economies of scale and could mean that industries will co-locate and so increased cost pressure might cause production shifts for a whole sector or supply chain.

DG Enterprise Study sectors

As discussed we used the price elasticities for four sectors from a similar study for DG Enterprise to inform our modelling: Manufacture of Glues and Gelatines, Manufacture of Basic Iron and Steel, Manufacture of Paper and Paperboard, and Manufacture of Ceramic Tiles and Flags. We did not review these sectors qualitatively.

Manufacture of Glues and Gelatines

- Manufacture of Glues and Gelatines (2462): The Commission's criteria suggest that this sector is not at risk of carbon leakage as costs are just 0.9% of GVA, while trade intensity is 25.9%. However, the sub-sector Gelatines has been deemed at risk of carbon leakage by The Commission's following a quantitative appraisal at this level of detail. Our results are inconclusive as the data are not adequate to deliver robust estimates.

Manufacture of Basic Iron and Steel and of Ferro-Alloys

- Manufacture of Basic Iron and Steel and of Ferro-Alloys (2710). The Commission's criteria suggest this sector is at risk of carbon leakage as the carbon cost impact is expected to be 10.6% of GVA, while trade intensity is 32.3%. Our modelling also suggests that the sector is at risk of carbon leakage; however, we find this to arise for the most part from a substantial decline in export demand and overall we estimate an EU production loss of 15.4%. Most interestingly, despite finding considerable evidence for a decline in domestic demand, we do not find evidence for import substitution despite extensive testing. We believe that this may be because import prices and domestic prices have moved together over the historical data and the two factors are therefore statistically indistinguishable. This is possible for a sector like Steel, where the product is a relatively homogenous commodity and traded internationally on a large scale.

Manufacture of Paper and Paperboard

- Manufacture of Paper and Paperboard (2112). The Commission's criteria suggest that this sector is at risk of carbon leakage as the carbon cost impact is expected to be 10.2%, while the trade intensity is also high (25.7%). Our modelling finds modest evidence of import substitution and a small reduction in EU production of 0.8%, but again as for any sector with moderate to high carbon cost impacts, we need to consider the impact of reduced profit on long term industry investment.

Manufacture of Ceramic Tiles and Flags

- Manufacture of Ceramic Tiles and Flags (2630). The Commission's criteria suggest that this sector is at risk of carbon leakage with expected cost impacts of between 5 and 30% of GVA and trade intensity of 28.6%. The quantitative analysis for this sector also suggests that the sector is at risk of carbon leakage and it is the sector most affected by import substitution. Overall we estimate a considerable production loss of 20% in the long term. However, the main caveat for this sector is that we modelled it at the maximum 30% cost bound; the carbon leakage will clearly be lower depending on the true cost impact.

Further avenues of research

The research findings suggest that, despite some data limitations, leakage will be significant in a small number of sectors which have both high production cost impact and high trade intensity. While we believe these findings to be robust, they provide just one part of the evidence to a complex and emerging policy issue. Therefore, the project team recommends that further research is required in the following areas:

- Our main recommendation is that sectors which might be at risk of carbon leakage on the basis of our additional criteria, or at the top end of The Commission's criteria are subject to further assessment. In particular, we recommend a focus on sectors where either the carbon abatement potential is limited, or the sector is important in the value added chain. There are also qualitative factors which need to be considered to obtain a better understanding of leakage and will require consultation with industry: an example is the co-location of one industrial process with another.

- Particularly we recommend a focus on industry structure and market segmentation as these criteria were most quoted in the literature, the implication being that these controlled the degree to which sectors could pass their costs through, and hence mitigate any impacts. Both national and international market structures were seen as important. But despite its recognised importance, industry structure was not easily comparable across sectors. Quantitative measures are available for some sectors mainly resulting from analysis of issues of competition, but there are gaps for sectors without such concerns and this type of analysis is often specific to certain time periods. As methodological approaches already exist, it may be possible to develop a standardised methodology focusing on the interaction between leakage and industry structure for particular sectors in future studies.

- To supplement the above, we also recommend that 'whole-economy' modelling studies are undertaken to understand the dynamics and inter-industry relationships across the economy, which have been identified as important after consultation with industry stakeholders, while also assessing second order effects such as the impact on employment and incomes feeding back to product demand.

- We also strongly recommend that both member state and EU statistical agencies improve the quality and richness of the data required to make assessments of carbon leakage. In some cases key economic data are found to be severely lacking: feedback from industry suggests that they fundamentally disagree with some of the sector specific data employed in this study, upon which some key policy conclusions are reached. Moreover, data are simply missing for a number of key indicators required to assess the risk of carbon leakage with greater levels of confidence. We found data to be missing in our alternative criteria suggestions and in the data required for the econometric analysis. The only counter to this informative critique is to improve the data sets available, in consultation with industry, policy-makers and academia, and hence provide a more robust evidence base for policy formulation

- This study represents just one approach to looking at carbon leakage and results are known to be conditioned by the level of sectoral disaggregation. We believe that a quantitative research approach could now be focused on certain sectors confirmed as important both to understand the complex interactions (eg vertical integration and co-location) between sectors rather than looking at sectors in isolation, and to understand the dynamic responses of firms with reduced profit margins in sectors which cannot pass on costs. Perhaps most importantly robust data sources to support additional criteria identified as important and undertaking modelling in key sectors need to be developed. The research should be undertaken in consultation with industry to ensure that the findings obtained are robust.

1 Introduction

1.1 Background and Context

In December 2009, the 15th Conference of the Parties (COP) took place in Copenhagen with the objective of agreeing binding commitments on greenhouse gas emissions (GHGs) for 2020 and beyond. The commitments were deemed necessary to put in place the building blocks for a comprehensive global emissions architecture to replace the binding Kyoto Protocol agreements which are due to end in 2012. Although the Copenhagen meeting was unsuccessful in developing legally binding commitments from all countries, most countries put forward pledges to the UNFCCC under the Accord, outlining the policy targets of each signatory nation with respect to reducing GHGs.

As part of the Copenhagen negotiations, the European Union (EU) re-iterated its position to reduce GHGs by 20% compared to the 1990 baseline, while re-affirming that the more ambitious 30% target is still an option if other countries pledge to reduce GHGs beyond their existing commitments. The EU ETS is a key policy tool to reduce GHGs, as it is a centrally controlled cap and trade system, covering a large proportion of industrial CO_2 emissions. However, ahead of the third phase of the EU ETS, which is due to begin on 1 January 2013, industry stakeholders have raised concerns that the additional cost of CO_2 brought about through the EU ETS will negatively impact on price competitiveness and, ultimately, lead to a shift in production to regions outside the EU. The shift in production will mean that CO_2 emissions are simply transferred from Europe to other world regions, resulting in a diminished total world reduction in emissions, this shift is known as carbon leakage[9].

In 2009, The Commission undertook an impact assessment study to interpret which sectors might be at risk of carbon leakage. In doing this The Commission's identified 164 sectors, defined at the NACE 4-digit level of industry classification, which might be at risk of carbon leakage. To do this, The Commission's proposed a set of criteria during the Directive negotiations based on the direct cost of the ETS to a sector, the indirect cost of the ETS through increased electricity prices and the proportion of trade relative to domestic production plus imports. These criteria were agreed and formed the basis of The Commission's assessment, as set out in the Directive. Some additional sectors were included in the list on the basis of a qualitative assessment. The justification for the inclusion of the measures used to form the criteria is as follows:

The EU outlined three measures, used in various combinations to identify sectors at risk of carbon leakage

- *Direct cost increase as a share of Gross Value Added (GVA).* This criterion is designed to assess the cost pressure of an EU ETS carbon price of €30/tCO_2 based on the known emissions of the sector. Intuitively, the higher the cost increase as a proportion of GVA, it is expected that carbon leakage is more likely to take place.
- *Indirect cost increase as a share of GVA.* This criterion is designed to assess the cost pressure of an EU ETS carbon price of €30/tCO_2 based on the known electricity input of the sector, and the carbon intensiveness of the electricity

[9] Carbon leakage is a measure of the increase in CO_2 emissions *outside* a country or region taking domestic mitigation action (in this case the EU) directly as a result of shifts in productions caused by asymmetrical carbon mitigation policy.

consumed. Intuitively, the higher the cost increase as a proportion of GVA, it is expected that carbon leakage is, once again, more likely to take place. It is important to note, that the indirect cost increase does not include the potential increase in the cost of production inputs, such as component parts of a manufactured product.

- *Extra-EU Trade intensity*. This criterion is designed to capture the trade component of leakage, in that it is expected that either exports will fall if export prices increase or imports will increase if domestic prices increase.

A sector meeting any one of the following thresholds in The Commission's assessment is deemed to be at risk of leakage:

- increase in production costs > 5% of GVA, and extra-EU trade intensity > 10%;
- increase in production costs > 30% of GVA
- extra-EU trade intensity > 30%

Overall, 164 sectors were identified by the EU to be at risk of carbon leakage. However, the degree to which individual sectors might be at risk is not identified fully in the assessment.

1.2 Objectives

Therefore the core objectives of the study are:

1 Identify the sectors at risk of carbon leakage in the EU, considering those criteria (increased production costs as a result of both direct and indirect emissions, and trade intensity) that have already been used to inform existing analyses, and potentially other criteria which might provide additional detail on the risk of leakage;

2 Estimate the degree of leakage for a range of sectors deemed to be at different levels of risk, in order to test The Commission's criteria (and possibly criteria developed as part of Objective 1). The degree of carbon leakage is assessed on the basis of not only a more stringent EU ETS cap but also the stringency of climate policy in other regions of the world as a result of commitments offered as part of the Copenhagen process. We also assess how different instruments (principally free allocation of allowances and border adjustment mechanisms (BAMs)) could affect the degree of leakage for these test sectors.

1.3 Report Structure

This report is divided in six subsequent chapters and a number of supporting appendices. The next chapter describes the carbon leakage literature, putting particular relevance on carbon leakage in the context of the sectors selected by DECC. Chapter 3 outlines the criteria devised to test whether a sector might be under threat of carbon leakage and also describes the methodology for the application of the criteria to identify sectors most at risk.

The next part of the report, Chapters 4-7 explains the method employed to test degree of leakage for the fourteen sectors. Chapter 4 explains the econometric method employed and a summary of the data used to derive Armington trade price elasticities, which are then employed in a sector framework model to assess the degree of leakage. A summary of the estimation results is provided in Section 4.4 while more detail is provided in the Appendices. Chapter 5 explains the structure of the sector framework model and its various underlying assumptions and its limitations with regard to assessing leakage. The detail of the scenario and sensitivity modelling assumptions are described in Chapter 6, while Chapter 7 describes the results of the modelling process.

Appendices A to J provide the econometric estimation results for each of the ten sectors. Appendix K presents tables of the criteria we identified.

2 Review of the Literature

2.1 Introduction

The aims of the literature review were:

- to cover comprehensively the carbon leakage literature; and
- to supplement this with in-depth reporting on selected sectors for further analysis in this study
- to provide elements of both a wide and a deep survey

The primary purpose of the wide literature review was to inform the development of criteria used to screen sectors at risk of carbon leakage. Therefore, while the key results of the literature are reported here for completeness, the main outcome of this part of the review was to populate a list of possible carbon leakage assessment criteria. This work, building on the literature review, is further described in Chapter 3.

The reporting structure in this chapter corresponds to the objectives of this chapter and has two main components.

The first (wide survey) covers literature grouped under the following headings:

- literature reporting on the development and use of economic models
- literature related to specific sectors and groups of sectors
- relevant wider literature
- in-depth literature on particular sectors ('deep dives')

The second part of the review was to attempt to qualitatively evaluate the criteria that were selected and to provide a background on the sectors selected. This section therefore reports the main sector findings which relate to the identified criteria, whilst also providing an important background to many of the sectors considered as part of the econometric and sector analysis discussed in Chapters 4-7. The preliminary evaluation of criteria has been done by describing the sectors in relation to the detailed criteria under the broader headings below which correspond to those used in Chapter 3 for criteria development:

- cost structure
- pass-through ability - which depends on how firms relate to their Markets
- abatement potential - resulting from Research & Development expenditure
- regulatory conditions - part of the Legal and Regulatory context

Each deep dive has a summary table which highlights key findings for each of the more specific criteria. The development of the criteria and their final selection, which is the main output of the literature review and deep-dives, is discussed in more detail in Chapter 3, as is the application of the criteria and the justification for the final sector selection for further analysis in the econometric analysis and sector models discussed in Chapters 4-7.

2.2 The Literature Addressing Carbon Leakage

The literature on carbon leakage is expansive, originating from a number of academic disciplines. This reflects the pertinence and multidisciplinary nature of the issue.

A large body of academic literature exists on the subject of carbon leakage across a range of economic and legal disciplines. In addition to these sources, the pertinence and breadth of this issue has led to widespread research by industry stakeholders. This chapter outlines the principal economic studies that exist on this topic from an economic modelling, sector and regional perspective and will offer a typology of the literature from other disciplines which offer insight in to the wider issues associated with carbon leakage.

Although useful as a stand alone piece of work identifying common themes and the level of comprehension and agreement in the research community, the principal reason for undertaking this literature review is to identify the main assessment criteria commonly used to determine the risk of carbon leakage. This will provide the basis for the assessment criteria listed in Chapter 3 which the consortium believes most accurately examine the degree and the nature of the risk of leakage in specific subsectors. A number of methodological approaches could be adopted to determine carbon leakage and so this chapter distinguishes between the main types of research and explores how they contribute to the debate on leakage.

The literature review was a crucial component in determining a master set of criteria. The studies below were reviewed and the assessment criteria used in the reports were noted and tallied so it was possible to identify which criteria were most cited. In practice this identified criteria that were significant or were readily available for each study.

As the studies are described below, there will be additional discussions on the types of criteria that were most common to the different modelling approaches. The consortium felt it necessary to include a variety of modelling studies and look at literature from business, trade and legal disciplines so as to better understand the multi-faceted nature of a firm's production location decision and the factors which cause shifts in production. Chapter 3 outlines the methodology used to refine this large set of criteria, derived from the literature, and the rationale for developing the final, shorter list.

2.3 Literature on the Development and use of Economic Models

A number of economic models have been used to identify the degree of carbon leakage at both the macro and microeconomic level in the short to mid-term. Leakage studies can be divided into:

- Computable General Equilibrium models (CGE) which calibrate a base year data assuming it is in equilibrium, and then calculate the effects of perturbing inputs, and
- long term scenario calculations, which are based on developing a description of a consistent set of circumstances

Studies can be forward or backwards looking, using data to anticipate future impacts or using historical data for ex-post evaluations of the impact of carbon pricing on production location decisions. The models tend to be computable general equilibrium (CGE) models. While econometric techniques are often used, indirectly in CGE models (e.g. via the estimation of elasticities etc), there are few substantive purely econometric-based studies.

Macroeconomic models

Macroeconomic models estimate the leakage rate from Annex I to Non-Annex I countries to be between 2% and 130%, as shown in Table 2.1. This upper bound was reported in Babiker (2005) which estimated that the Kyoto protocol could have the perverse effect of increasing emissions e.g. if there was a widespread pollution haven effect whereby relocation of industry to locations with laxer environmental standards led to relatively more emissions intensive production practices than in Annex I countries. Moreover, the Babiker (2005) estimate of 130% carbon leakage highlights the importance of the assumptions required to quantify carbon leakage, these assumptions can be divided into general modelling assumptions (eg perfect information) of the CGE framework and direct input assumptions, (eg relative carbon prices). Owing to the number of assumptions required and the transparency by which they are reported it is not possible to assess the carbon leakage results against all of the input assumptions, however, it is worth discussing some of the key assumptions and their general impact, this can be illustrated through the Babiker 130% result:

- in the scenario which yields this result Babiker assumes that the entire energy-intensive sector is homogenous, and so production for the entire sector shifts as a result of the increase to cost
- Babiker assumes increasing returns to scale for the energy-intensive sector, but no other sectors, and so as production shifts outside the OECD (the region taking action), non-OECD production becomes increasingly price competitive, leading to greater than 100% carbon leakage
- the cost of relocation is implicitly assumed to be zero, as are transport costs
- the CGE model assumes perfect competition
- CGE models also often assume perfect information over space and time and the operation of fully-informed rational agents.

A number of macroeconomic modelling studies were developed, mostly in the early 2000s, anticipating the impact of the Kyoto Protocol (1997) on emissions levels in Annex I and Non-Annex I countries. Leakage is assumed to occur through global energy markets and due to the mobility of capital and goods. As discussed, the results from these studies can vary greatly, with estimates of leakage rates of emissions from Annex I to non-Annex I countries between 2 and 130%, depending on modelling techniques and assumption sets.

TABLE 2.1: LEAKAGE UNDER THE KYOTO PROTOCOL, SELECTED MACROECONOMIC MODELS

Author	Title	Model	Summary of findings
Babiker (2005)	Climate change policy, market structure and carbon leakage	Dynamic multi-region CGE model assuming: oligopolistic competition of Heckscher-Ohlin goods with increasing returns to scale.	Global leakage rate from OECD countries covered by Kyoto between 50-130%. Leakage mainly occurring in China, India and dynamic Asian economies.
Babiker (2001)	Subglobal climate-change actions and carbon leakage: the implication of international capital flows	Regionally disaggregated dynamic (MIT-EPPA) CGE model of the world economy which uses a GTAP data set to provide projections of world economic development and emissions along with analysis of proposed emissions control measures	Strong results from the model show that carbon leakage is virtually unaffected by the presence of restrictions on the mobility of international capital.
Bernstein (1999)	Global impacts of the Kyoto agreement: results from the MS-MRT model	A multi-sector, multi-region trade model (MS-MRT) using GTAP data	Leakage rate is estimated to be between 8-20%
Bollen et al. (2000)	Decomposing carbon leakage-an analysis of the Kyoto Protocol	An AGE model using IPCC-SRES A1 and B1 reference scenarios	Analyses the effects of unilateral action and permit trading in Annex I countries and finds typical values of leakage rates to be around 20%, it is dependent on the policy and affects GDP more than income
Burniaux & Truong (2002)	GTAP-E:An Energy-Environmental Version of the GTAP Model	Incorporates energy substitution in to the GTAP (CGE) model to better represent the energy-economy link	Leakage rate is calculated to be 4% under the Kyoto Protocol
Burniaux & Martins (2000)	Carbon emissions leakage: A general equilibrium view	Using a CGE model, uses different supply elasticity of coal and assumptions on the tradability of permits	Leakage rate is calculated to be 2.1%-22.9% under the Kyoto Protocol
Gerlagh Kuik	Carbon leakage with international technology spillovers	CGE (GTAP-E) model of a globally integrated energy market with endogenous energy-saving technology and international technology spillovers	Carbon leakage becomes negative for moderate levels of international technology spillover.
Kuik Gerlagh	Trade liberalisation and carbon leakage	Static, multi-region, multi sector, CGE (GTAP-E) model	Import tariff reductions further increase the leakage rate. The main reason for leakage is the reduction in world energy prices
Labandeira et al. (2009)	An integrated approach to simulate the impacts of carbon emissions trading scheme in Spain	A combined modelling approach using a CGE model to assess the impact on sectors and identify cross-industry changes, and a partial equilibrium model to suitably model the electricity system	The EU ETS will cause a rise in power prices in Spain, a slight decline in GDP, and minor inflation. Results showed that when the list of sectors covered by the EU ETS is expanded, the negative impact declines for individual sectors and in aggregate

TABLE 2.1: LEAKAGE UNDER THE KYOTO PROTOCOL, SELECTED MACROECONOMIC MODELS (CONTINUED)

Author	Title	Model	Summary of findings
Light et al. (1999)	Coal markets, carbon leakage and the Kyoto Protocol	Light CGE model	Leakage rates are between 20-21% depending on the homogeneity of coal.
Manne & Richels (1998)	The Kyoto Protocol, a cost-effective strategy for meeting environmental objectives?	Model for Evaluating the Regional and Global Eeffects of greenhouse gas reduction policies (MERGE). It is an inter-temporal market equilibrium model	Leakage rates estimated to be around 20%
McGibben (1999)	Emissions trading, capital flows and the Kyoto Protocol	Multi-region, multi-sector CGE model which focuses most on international trade and capital flows	Leakage rates estimated to be around 6%
Paltsev (2001)	The Kyoto Protocol: Regional and sectoral contributions to carbon leakage.	A static multi-sector, multi-regional computable general equilibrium model used to assesses the sectoral and regional determinants of the leakage	Main contributors to leakage are the chemical and iron and steel industry. The leakage rate has a sensitivity range of 5-15%

Source(s) : Climate Strategies. Adapted from Climate Strategies, Dröge, Monjon and Schloemer (forthcoming).

TABLE 2.2: SECTORAL STUDIES ON CARBON PRICING EFFECTS

Author	Title	Method	Geography	Aggregation	CO_2 price	Ranking/list of sectors at risk
Asuka (2009)	ETS and international competitiveness issue	Calculation of a sector's NVAS and MVAS in relation to GVA	Japan		3000 ¥/t CO_2 (approx €27/t CO_2)	1. Pig Iron 2. Cement 3. Ferro-alloys 4. Petrochemical basic products 5. Coal products 6. Industrial soda products
Carbon Trust (2008)	EU ETS impacts on profitability and trade. A sector by sector analysis	Based on analysis by Climate Strategies, Hourcade et al. (2007)	UK	4 digit SIC	€20/t CO_2	1. cement/clinker, steel from blast oxygen furnaces, aluminium. 2. Fertilizers & nitrogen compounds, other inorganic basic chemicals, pulp, paper and paperboard
Commission Services (2008)	Commissions Services paper on Energy Intensive Industries exposed to significant risk of carbon leakage	Product price increase assessed after introducing carbon costs	EU 27	8-digit (partly aggregated PRODCOM)	€30/ t CO_2	1. Cement clinker 2. Quick lime 3. Chlorine 4. Grey Portland cement 5. Ammonium nitrate 6. White Portland cement
Citi Group Investment Research (2008)	Carbon Pollution Reduction Scheme	Assessment of impact of the CPRS on market capitalisation for companies in Australia	Australia	Installation level	AU$20/ t CO_2	1. Energy developments (power sector), 2. Cement, lime, construction materials, 3. steel, 4.paper
Climate Strategies, Hourcade et al (2007)	Differentiation and dynamics of EU ETS industrial competitiveness impacts	Risk of leakage is determined by carbon cost increase (direct and indirect) relative to a sector's GVA.	UK	4 digit SIC	€20/ t CO_2	1. cement/clinker, steel from blast oxygen furnaces, aluminium. 2. Fertilizers & nitrogen compounds, other inorganic basic chemicals, pulp, paper and paperboard
de Bryun et al.(2008)	Analysis of competitiveness impact of the EU ETS in Holland	Partial microeconomic framework to identify the potential cost price increase under different allocation scenarios	Netherlands	2-4 digit SIC	€20/ t CO_2	1. Cement, calcium, gypsum; 2. Fertilizers & nitrogen compounds, 3. Iron & steel; 4. Aluminium; 5. Inorganic chemicals; 6. Other base chemicals

TABLE 2.2: SECTORAL STUDIES ON CARBON PRICING EFFECTS (CONTINUED)

Author	Title	Method	Geography	Aggregation	CO_2 price	Ranking/list of sectors at risk
Graichen et al. (2008)	Impacts of the EU Emissions Trading Scheme on the industrial competitiveness in Germany	Calculation of a sector's NVAS and MVAS in relation to GVA	Germany	4 digit NACE	€20/ t CO_2	1. cement, 2. lime, 3. fertilizers and nitrogen compounds, 4. basic iron and steel, 5. aluminium, 6. paper
Houser et al (2008)	Levelling the carbon playing field. International competition and US climate policy design	Final sales value after the introduction of a carbon price	USA	2 digit SIC	-	1. Alkalis & chlorine 2. Lime 3. Pulp mills 4. Primary aluminium 5. Smelters 6. Nitrogenous fertilizers 7. Newsprint mills
Morgenstern et al. (2004)	The near-term impacts of carbon mitigation policies on manufacturing industries		USA	4 digit SIC	cost increase per $ of carbon charge	1. petroleum refining, 2. products of petroleum and coal, 3. Lubricating oils and greases, 4. carbon black, 5. asphalt paving mixtures & blocks, 6. lime
Sugino et al (2010)	Carbon mitigation policies on Japanese manufacturing industries and competitiveness issues	Used the approaches in Morgenstern, The Commission's and the Waxman-Markey bill to assess the risk of leakage for Japanese industry	Japan		4000 ¥/ t CO_2	Differs depending on the methodology used

Source(s) : Climate Strategies. Adapted from Climate Strategies, Dröge, et al (forthcoming).

Sectoral models which include carbon pricing effects

Since the development of unilateral and more focussed carbon pricing policies, the debate on leakage has evolved to consider sector specific impacts. Economic modelling has more recently been applied to different regions where carbon pricing has or is anticipated to be introduced. This aims to assist policymakers by identifying the source of leakage more precisely, allowing for a targeted policy response. Identifying sectors at risk requires a degree of subjectivity and models will differ in their assumptions on CO_2 pricing, future policy designs and on the level of data aggregation and sector definition. Subsequently, multiple studies which cover the same geographical region may identify different sectors at risk, as shown in Table 2.2.

These sectoral studies were found to contain particular information on criteria one can use regarding cost pass-through ability and the impact that carbon costs will have on trade patterns.

2.4 Literature related to specific sectors and groups of sectors

Most recently, studies have looked at a particular dimension of the leakage debate in great detail for a few sectors.

In addition to the model based economic studies, there are individual studies, see Table 2.3, which explore a group of sectors in depth, focussing either on a particular group of assessment criteria such as Mohr et al. (2009), which looks in-depth at trade flows and cost structures (providing a corresponding indication of pass-through ability and cost impacts), or like Monjon and Quirion (2009) again uses modelling techniques to assess the impact of carbon pricing under different policy scenarios. These studies often chose sectors with a degree of similarity for this analysis.

The range of different assessment approaches gives an indication of the breadth of the methodological approaches that can be used to determine leakage. Because of this variety, this selection of studies was very useful for cataloguing and developing the final list of assessment criteria for determining carbon leakage as listed in chapter 3. They provided insights on a number of issues that impact on a firm’s risk of leakage including: abatement potential, regulatory frameworks across the world, trade flows, cost structures, market structures, profits and pass-through ability, the impacts of allocation methodologies, international trade patterns and transport costs.

For example, Climate Strategies (2009), Monjon and Quirion’s CASE model incorporates the impacts of: transport costs relative to CO_2 cost, market structure (both domestic and global), the share of carbon costs in overall cost structure, differences in carbon cost shares across regions, product differentiation and market segmentation, abatement costs and abatement options for both indirect and direct costs and also model the impact of the legal and political environment. These were all identified as important indicators that determine the industries’ reaction to an increase in carbon costs.

TABLE 2.3: SECTOR STUDIES ON CARBON LEAKAGE AND COMPETITIVENESS

Author	Title	Method	Geography	Sectors	Results
Baron et al. (2009)	Sector analysis of competitiveness impacts, including cement, aluminium and steel - working draft	Analysis of production methods, abatement potential, regulatory environment, trade flows and existing models on sector leakage.	Global	Cement, aluminium, steel and refineries	Using 2005-2006 data, there is no evidence of a change coinciding with the EU ETS but 2 years of data is not comprehensive enough to accurately determine the impact. Trade flows and carbon prices need to be monitored.
Climate Strategies, Mohr et al. (2009)	Trade flows an d cost structure analysis for exposed industries in the EU-27	Analysis of production process, input structure (& energy use), trade flows and intensities	EU 27	Aluminium, basic iron & steel and Ferro-alloys, fertilizers and nitrogen compounds, other basic inorganic chemicals, paper and paperboard.	Growth in trade volume in these sectors is driven by higher world market prices, shares of intra-EU trade in total trade have been constant, major trade partners are similar across sectors analysed & big changes in trade partners' positions are rare during 2003-2007.
Climate Strategies, Monjon & Quirion (2009)	Addressing leakage in the EU ETS results from the CASE II model	Quantitative assessment of 9 scenarios outlining remedial policy options for addressing leakage	EU 27	cement , aluminium , steel and electricity	Simulations show that even in the case of full auctioning, without 'anti-leakage' policy the leakage ratio is 10%. This is due to zero leakage in the power sector so leakage rates are lower in steel (39%), aluminium (21%) and cement (20%). Results are dependent on Armington elasticities.
Climate Strategies, Smale et. al (2006)	The impact of CO2 emissions trading on firm profits and market prices	Cournot representation of an oligopoly market which analyses the extent of cost-pass through, changes in output, changes in UK market share and changes in firm profits.	UK	Cement, newsprint, steel, aluminium and petroleum	Sectors anticipated to profit in general, with a modest loss of market share in the case of steel and cement, and closure in the case of aluminium

TABLE 2.3: SECTOR STUDIES ON CARBON LEAKAGE AND COMPETITIVENESS (CONTINUED)

Author	Title	Method	Geography	Sectors	Results
European Commission Economic Paper 298 (2007)	Imposing a unilateral carbon constraint on energy-intensive industries and its impact on their international competitiveness – Data and analysis	The paper calculates the product price increases required to maintain unit profits at present levels, based on probable allocation in the EU ETS up to 2020. It also looks at pass through cost increases	EU 27	Iron & steel, aluminium, copper, other non-ferrous metals, cement and lime, glass, ceramics, paper & pulp, chemical	The impact of a €20/t co2 EUA should raise output prices for most sectors by between 0.1-5%, primary steel 6.5-12%, primary aluminium 7.5-10%, building materials 20-45% & ammonia 14-25%
McKinsey (2006)	EU ETS review of competitiveness		EU 27	Power generation, Steel, pulp and paper, cement, refining, aluminium	At 20€/t CO2, the power sector is likely to benefit in the short and medium term and regain the ability to invest in new power plant, steel BOF will have significant impacts on its competitiveness and EAF to a smaller extent, pulp and paper only partly compensated through free allowances, net impact on cement is uncertain with different intra-Europe impacts, neutral impact on refining, large indirect cost for primary aluminium and marginal increase for secondary.
The Carbon Trust (2004)	Economic model of oligopoly behaviour predicting the impact of CO2 pricing on EBITDA, sales, number of firms, investment in energy efficiency and emissions abatement and degree of cost pass through		UK	electricity, cement, newsprint, steel, aluminium	Models the results all these variables in all sectors in Phase I, II and III of the EU ETS

Source(s) : Climate Strategies.

2.5 Relevant wider literature

A number of other bodies of academic literature provide insights on the impacts of carbon pricing on a firm and the subsequent risk of leakage this may induce

In trade literature, the issue of the pollution haven hypothesis may be revisited, whereby differences in environmental regulation may lead to a relocation of industry to areas with laxer policies. This theory is implicitly rather than explicitly captured in the macroeconomic modelling studies which anticipate an increase in emissions in non-Annex I countries following the introduction of the Kyoto protocol. Trade studies on the pollution haven hypothesis (e.g. Zeng and Zhao (2009) and Cole (2005) offer additional insights on the relative impact of carbon costs (and environmental costs more broadly) on a firm's cost structure and how this will impact not only the production location decision but also the degree of industrial agglomeration, FDI and the capital intensity of production.

Socio-economic implications of high levels of leakage rates are addressed in macroeconomic studies which look at employment effects. In particular, employment within a carbon pricing zone could be severely impacted if the leakage rate is high. A study by ZEW on behalf of WWF offers a literature review on the existing studies which assess this. As leakage occurs principally in the manufacturing sectors, it could lead to a restructuring of the economy, the scale of which is unclear.

Management and business studies also provide assessments of the impact of carbon pricing on a firm's production location decision. Understanding issues such as investment cycles, risk, cost structures and business models are part of how firms' decisions affect their reaction to additional carbon costs.

Legal literature is also a relevant source of information for understanding the issue of carbon leakage more fully, particularly in relation to remedial policy measures. Although this is less applicable to developing a list of assessment criteria for determining the risk of carbon leakage than some of the aforementioned groups of studies, it is of high importance when assessing the legality of issues such as free allocation, border tariffs and subsidies etc. The interaction between domestic and international environmental law and international trade law is becoming increasingly pertinent for the discussion on carbon leakage at European level.

2.6 In-depth literature on particular sectors ('deep dives')

As section 2.3 demonstrates, a number of studies have explored the anticipated impact of carbon pricing on the risk of leakage in subsectors of the European economy using a combination of qualitative and quantitative criteria to determine the risk of leakage.

In addition to these modelling studies a number of research papers have also chosen to look at a particular sector in depth, see Table 2.4. This again adds another dimension of understanding to the exact nature of the risk of leakage the sector may face. These studies have been undertaken by industry, governments and academia. A selection of these studies and their main conclusions for a few energy-intensive industries covered by the EU ETS are listed in the table below.

The criteria in these studies were also noted and used to supplement those derived from the modelling studies listed in Section 2.3 to create the final list, as outlined in Chapter 3. In order to assess the validity and the economy-wide applicability of the chosen list of criteria a template was developed for Copper production (NACE code 2744), specifically identified by The Commission[10] as being at risk of carbon leakage.

[10] To the extent at which the required data and information was in the public domain.

TABLE 2.4: IN-DEPTH SECTOR STUDIES

Sector	Author	Title	Results
Coke oven and refined petroleum products	Julia Reinaud (2005)	The European Refinery under the EU ETS. Competitiveness, trade flows and investment implications	Opportunity to alleviate the loss of competitiveness in 2005 when demand was high and capacity was saturated. Amortising the impact of CO_2 costs may be easiest.
	Daniel Radov & Per Klevnas (NERA 2007)	The Competitive Context of the European Petroleum Refining Industry in Light of the EU ETS	At €20 and €30/tCO2, emissions costs for EU refineries are likely to be around €4-5 and €6-7 per tonne of product, respectively. The full costs of emissions under the ETS costs therefore represent a potentially significant proportion of margins for European refiners.
	EUROPIA –European Petroleum Industry Association	EUROPIA position on the proposed Directive amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emissions allowance trading scheme of the community	Cites that “The additional costs of increasing auctioning ... will significantly reduce margins and profits ... create a strong competitive disadvantage, discourage new investment in processing units ... and weaken EU refining and security of supply in Europe”
Cement	CEMBUREAU – The European Cement Association (CSI)	Cement Sustainability Initiative	Cites that the CSI modelling work has shown that if carbon costs in regions with absolute carbon caps are passed through, changes in trade patterns are likely to occur as production shifts to lower cost regions. The net result is that higher emissions are likely to result, particularly if transport is included. A mechanism such as border carbon adjustments applied to imports would mitigate most of these effects
	Phillipe Quirion & Damien Demailly, (2006)	CO2 competitiveness, abatement and leakage in the European cement industry under the EU ETS: grandfathering versus output based allocation	Grandfathering and output-based approaches have very different impacts on competitiveness and emissions abatements in the cement sector. Grandfathering 50% of past emissions to cement producers is enough to maintain aggregate profitability at its business-as-usual level, but with significant production losses and CO2 leakage. For an output-based allocation over 75% of historic unitary (tCO2/tonne cement) emissions, the impact on production levels is insignificant, abatement in the EU is much lower, but there is almost no leakage
	Boston Consulting Group	Assessment of the impact of the 2013-2020 ETS proposal on the European Cement Industry	Based on the expected cost of production in the EU assuming the carbon cost of CO2 versus the cost of producing in non-ETS countries, clinker and cement production in the EU is not competitive without free allowances allocation. As a result, the “wise businessman” will prefer to relocate production to more competitive countries, this leading to production off-shoring.

TABLE 2.4: IN-DEPTH SECTOR STUDIES (CONTINUED)

Sector	Author	Title	Results
Basic iron and steel and of Ferro-alloys	EUROFER- European Confederation of Iron and Steel Industries	EUROFER statement on ETS implementation (Nov 2009)	Cites that: Reduced access to free allowances for the steel industry... is against both the spirit and the letter of the Directive.
	Damien Demailly and Philippe Quirion	European Emission Trading Scheme and competitiveness: A case study on the iron and steel industry	The Study assesses the impact on profitability and production and concludes that competitiveness losses are small. We prove this conclusion to be robust. Hence arguments against tightening the environmental stringency of the ETS in Phase II are not justified on grounds of competitiveness loss
Aluminium production	EAA – European Aluminium Association	Press release: Future of the European aluminium industry remains in jeopardy following European Commission proposals on Emissions Trading Scheme	Cites: There is no environmental benefit to include aluminium recycling plants in the ETS. Calls for: More concrete measures (in addition to free allocation) to mitigate the CO2 cost pass through into electricity prices for the Aluminium sector. For the sector's continued exclusion from the EU Welcomes the Commission's proposal to allocate free allowances on the basis of benchmarking.
	IEA information paper (2007)	Climate policy and carbon leakage. Impacts of the European Emissions Trading Scheme on Aluminium	The period of review was difficult to observe impacts on the aluminium sector but the sector had not experienced carbon leakage to date.

Source(s) : Climate Strategies.

2.7 Deep-dive to verify the usefulness and validity of the chosen assessment criteria

In order to test the validity and comprehensiveness of the criteria list in chapter 3 (derived from the literature review detailed in this chapter), they were used as a template for deep dives into the copper (Box 2.1 provides an overview) and pulp and paper industry to ascertain whether or not these criteria (used in combination) provide a comprehensive overview of a sector, so as to better understand the nature of the risk of leakage that it might face. The reporting structure in this section and in sections 2.8 and 2.9 were designed to match the model used in Chapter 3 for development of the Criteria. As identified in the introduction to this section, the sector discussions are grouped in the following structure:

- cost structures
- pass-through ability
- abatement potential and
- regulatory conditions

Cost structures Understanding a firm's cost structure will contextualise carbon costs relative to other costs in a sector's cost schedule (both in terms of other variable production costs and also relative to output based metrics such as Gross Value Added (GVA). This will help to understand the extent to which carbon costs impact on a firm's production and investment location decisions.

Pass-through ability When faced with carbon costs, firms have the option to pass on their carbon costs by increasing their product prices (and potential facing loss of markets) as an alternative to reduced profit margins and/or the relocation of production to areas outside of a carbon pricing zone. The ability of a firm to increase product prices can be measured by their cost pass through rates. A sector's ability to pass through additional carbon costs are dependent on a number of both local and international factors, discussed further in chapter 3. They are not directly observable because pricing strategies are again dependent on a number of factors; not just carbon costs. As such, the sector deep-dives offer qualitative assessment on the likelihood of a sector's ability to pass through carbon costs.

A criterion which affects a sector's pass-through ability could be looked at in isolation (other things being equal). Table 2.5 offers a list of indicative factors which suggest what pass-through rates might be for different criteria. However, in reality, these different criteria will be combined and so some subjectivity is necessary to determine their weighting and the overall likelihood of a sector's ability to pass through carbon costs. The sector deep-dives were constrained by the availability of information on each of these criteria but using available information, do offer a broad indication of pass through ability.

TABLE 2.5: INDIVIDUAL CRITERION'S IMPACT ON A SECTOR'S COST PASS THROUGH ABILITY

Pass through ability		Low	High
Local factors	Profit margins	Small	Large
	Substitutability of final products	High	Low
	Overall demand elasticity	High	Low
	Market share	Small between lots of firms	Monopoly power
	Market size	International	Local
	Product differentiation	Low	High
	Service differentiation	Low	High
International factors	Import volumes	High	Low
	Export volumes	High	Low
	Armington elasticity	High	Low
	Extra-EU trade intensity	High	Low

Source(s) : Climate Strategies and Entec.

Abatement potential A sector has the option to reduce their carbon costs by introducing policies and technologies that will reduce the amount of carbon that they emit during production. Abatement options will be sector-specific, and their rate of implementation will be determined by the relative prices of abatement and carbon.

Regulatory conditions Regulatory conditions will be another factor which determine if and where a sector may relocate to following the introduction of carbon costs. Carbon pricing is not the only type of environmental policy that may lead to increased costs for a sector. Taxes, subsidies and standards need to also be factored into a firm's production location decision and contextualised relative to carbon costs incurred during production. In addition, the operating environment outside of a carbon pricing needs to be considered. Business policies in more general terms need to be considered (again in relation to taxation rates) as well as the quality of infrastructure and production capacity (including labour force skills). The additional costs as a result of heavy regulation might also lead to lower global market shares for EU producers, or dampened profits.

The following sections aim to explore sector characteristics in terms of these four broad categories. The content of these sections is wholly dependent on the information that was accessible in the public domain and so will differ between sectors.

Copper production NACE code 2744

BOX 2.1: COPPER PRODUCTION, INDUSTRY SUMMARY

- **EC Criteria:** Cost/GVA% is 5.5%, Trade Intensity is 34.6% therefore **at risk**
- Energy and capital intensive production process with **high sunk costs**
- **Transport costs are low** relative to the value of the product
- **Price elasticity of demand** is -0.02 to -0.04 in the short run & -0.12 to -0.20 in the long run. Only a **few substitutes** exist; principally aluminium
- **Naturally concentrated market:** 87% of reserves are located in 12 countries.
- **Highest demand growth** in South East Asia, Latin America & CIS
- Limited technological abatement potential for extracting & refining copper

Source(s) : Climate Strategies.

Copper production is listed as one of The Commission's 164 sectors exposed to a significant risk of carbon leakage in Phase III of the EU ETS, pursuant to Directive 2003/87/EC. According to The Commission's analysis, the copper sector's indirect and direct costs from carbon pricing are 5.5% of the sector's Gross Value Added (GVA) and its trade intensity with non-EU countries is 34.6%. .

Cost structures

The copper production process is energy intensive and so the electricity-related emissions are likely to be high. The production process can be decomposed in to extraction and refining Copper needs to be extracted from mineral ores. This is a capital intensive process and so copper production facilities are often located near to mining facilities, as such, there are high sunk costs associated with copper production. The energy intensity of extraction will depend on the levels of copper deposits in each mine. There are two principle ways of refining copper once extracted (scrap can also be used where available), pyrometallurgical processes and hydrometallurgical processes (SXEW). The former is the most energy intensive, on average requiring 24,191.6MJ of energy per tonne of copper, whilst the latter requires 18,215.2MJ per tonne; this process is principally used for sulphide ores. Production using scrap only requires 11,535.7 MJ per tonne of copper. Using scrap may be a potential abatement option, but will be constrained by physical availability.

Transport costs for copper are low compared to the value of the product and falling. Lanz et al. (2009) confirm this by analysis recent trade patterns in copper and concluded that transport costs do not currently impede firm mobility in the copper industry. Because of the falling transport costs, the sector has become increasingly open to international competition. This may be a reason for the high measure of trade intensity identify by The Commission.

Pass-through ability

Copper is a commodity which has been used for over 8,000 years. Its versatility means it is used in construction, electronics, communications and the transport industry. It is a homogenous product which is of similar quality regardless of which refining route is taken and the location of its extraction.

Studies (e.g. Labys et. al 1999) have shown copper usage to be very pro-cyclical and principally driven by changes in demand from downstream sectors. It is likely that following the economic downturn, demand for copper has declined, particularly from the construction industry, however this trend is likely to reverse as global economic growth becomes more buoyant. Short term price fluctuations are driven by the changing patterns of demand because copper is a commodity and changes in demand will have a large impact on both the product price and profits. Demand for copper is strongly linked to economic and industrial growth and consumption levels particularly for regions in earlier stages of development as infrastructure is being developed. Lanz et al. (2009) models anticipated growth in copper consumption until 2015 and South East Asia (in particular China), Latin America, CIS all have the highest anticipated increase in demand.. In the short run, there are likely to only be a few substitutes for copper; principally aluminium. However, aluminium production (Nace Code 27:42) is also covered by the EU ETS. It is an energy-intensive and highly traded good and so the sector may face similar impacts or stronger cost impacts from the introduction of carbon pricing because of the high associated process emissions. ,

Due to the multiplicity of its application and the lack of any real substitutes, the price elasticity of demand for copper is low in the short run. A number of studies (Evans and Lewis 2005, Vial 2004 and Lanz et al. 2009), estimate the global short-run price elasticity of demand of copper to be between -0.02 and -0.04. This increases to between -0.12 and –0.20 in the long run as consumers are less constrained by their existing capacity and technology that require copper as an input. Lanz et al. (2009 argues that even in the longer term, the price elasticity of demand of copper may be low in the longer term because of versatility of the product and its longevity of use.

Copper reserves, and supply, are concentrated in a few regions (USGS 2008); approximately 87% are located in 12 countries that represent the main suppliers and so the copper extraction market is highly concentrated. Geographical circumstances necessitate a high degree of international trade. In Europe, Poland has the highest level of copper reserves.

Kuckshinrichs et al (2007) calculates that in the near future, this high level of demand will exceed the current production capacity of the sector. Large investments will be required. Non-OECD countries have already seen their relative share in the copper production market increase in the last decade and are now the location of most major copper productions and of exploration investment in the sector. This is likely to be as a result of both physical availability of copper reserves and also the anticipation of faster growth in these regions. The distribution of copper mining is constantly changing due to reserve depletion and the associated ease of extraction. Unilateral carbon pricing will be an additional factor for investors with operations in Europe to consider when making production location decisions, though these are often constrained by the physical availability of copper reserves. Given the homogeneity of copper, the Armington elasticity (elasticity of substitution between imported and domestically produced goods) of copper is likely to be low. Intermediary copper products in particular are highly traded. The value of trade in copper commodities was approximately 75% of the value of total copper usage in 2007 (adapted from Lanz et al. 2009 & ICSG 2008a).

Cost pass through ability is likely to be low given the fact that copper is a commodity and the price is determined in the market not by installations in regional markets.

Abatement potential

There are currently only a limited number of technological processes for extracting and refining copper. Although the SXEW process is less energy intensive, it takes longer and is only suitable for sulphide ores. The use of scrap copper is less energy and emissions intensive but limited by its availability.

Regulatory conditions

Tariffs are applied on copper products (concentrate blister and refined copper) in different regions.

Key outcomes of Copper 'deep dives'

The assessment criteria in chapter 3 were applied, where information is available, and gives a comprehensive overview of the sector. This information allows for a deeper understanding of why the copper sector faces a risk of leakage. The production process is quite energy intensive and given the fact that copper is a commodity, product prices and associated profits are determined by the market. As such, carbon costs have the potential to make up a large proportion of the sector's cost structure. The sector is anticipated to increase capacity in the near future to meet growing demand. The location of this demand is mainly in non-European countries and so the likelihood of increased capacity investment outside of Europe is likely to be high which could be exacerbated by increasing carbon costs in Phase III of the EU ETS.

Manufacture of pulp NACE code 2111

Manufacture of pulp (NACE code 2111) is considered as deemed to be exposed to a significant risk of carbon leakage.

The assessment made by The Commission shows that the increase of production costs as a proportion of the gross value added is lower than 5%. However, the intensity of trade with third countries, defined as the ratio between the total value of exports to third countries plus the value of imports from third countries and the total market size of the EU, is 46,1%.

Using the criteria developed by the project consortium we have chosen to focus on the sector structure and in global patterns of trade to understand better the risk of carbon leakage of the pulp manufacture sector.

The main source used for statistical information about the pulp industry is CEPI[11] Key Statistics 2008.

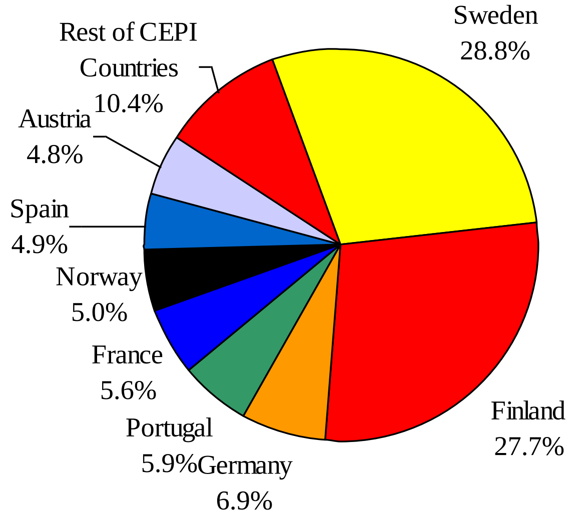
[11] CEPI members are : Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Norway, Poland, Portugal, Romania (New Member as of 2008), Slovak Republic, Spain, Sweden,
Switzerland, the Netherlands, United Kingdom.

Pulp industry structure

The EU pulp industry is dominated by Scandinavian countries, responsible for around 60% of CEPI countries production. This is due to their proximity to wood resources, the main raw material of pulp production.

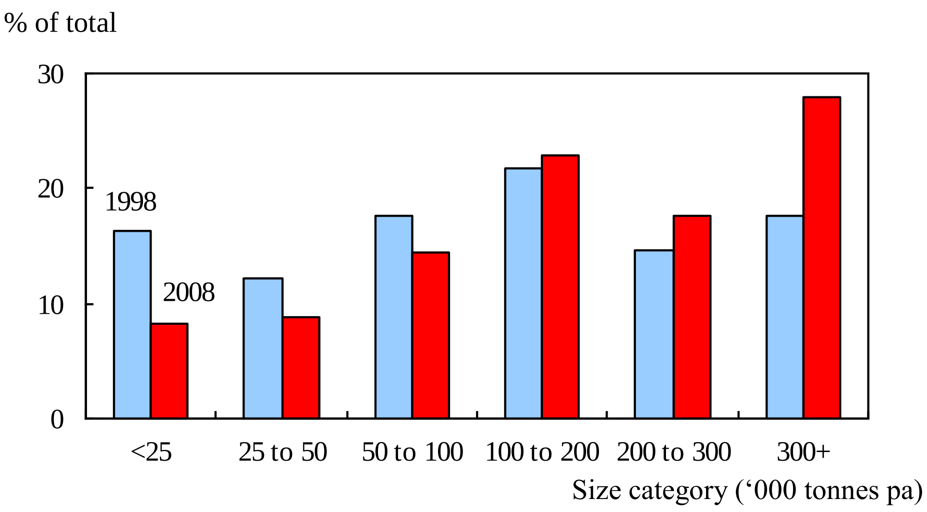
The sector is heterogeneous as regards size of the production mills, but shows a trend of increasing size of mills in the last ten years. Larger size mills are located in Sweden, Finland and Norway (BREF, 2001).

CHART 2.1: PULP PRODUCTION BY CEPI COUNTRY IN 2008



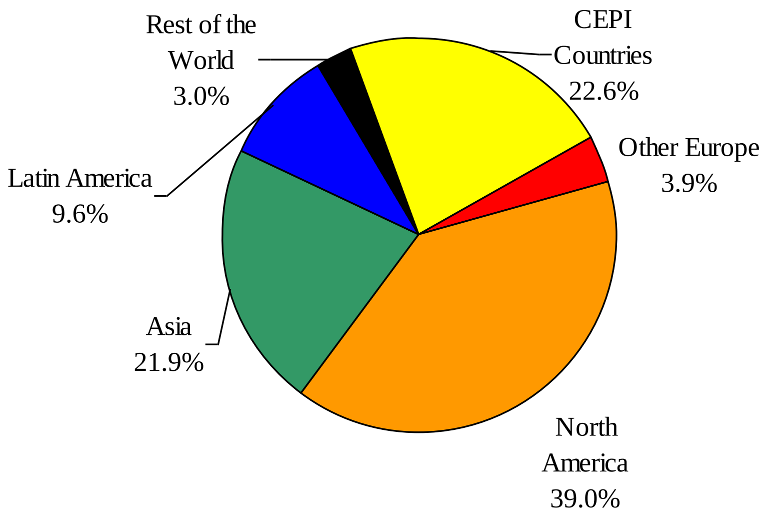
Source(s) : CEPI 2009.

CHART 2.2: NUMBER OF PULP MILLS BY VOLUME



Source(s) : CEPI 2009.

CHART 2.3: PULP PRODUCTION BY REGION IN 2007



Source(s) : CEPI 2009.

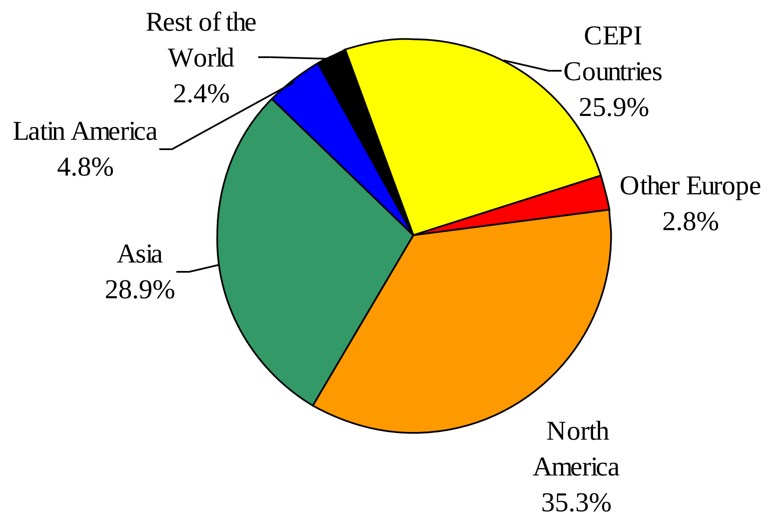
Pulp production in CEPI countries has increased steadily in the last years and has been met by a decreasing number of mills.

Global patterns of trade

Global pulp production and consumption is dominated by North America, followed by Europe and Asia.

Europe as represented by CEPI countries is a net importer of pulp, with a ratio of imports/exports close to 4. However, the ratio has decreased in the period 2004-2008. The main pulp export partners of CEPI countries are Asian countries (62.6% of total exports), followed by other European countries. The main importer of pulp to

CHART 2.4: PULP CONSUMPTION BY REGION IN 2007



Source(s) : CEPI 2009.

European CEPI countries is Latin America (55.3%) followed by North America (34.9%). Imports from Latin America have increased steadily since 2004, while imports from North America have decreased significantly.

The role of emerging economies providing low cost products in the global market has been increasingly significant. Exports from emerging economies grew by 15.4% between 2002 and 2006, while world exports grew at an average annual rate of 10.6%.

A study by Global Production[12] shows that pulp imports from emerging economies have a higher trend to cross regional borders (as reflected in the relative size of intra and extra-regional import flows) than do wood and paper imports. Thus, there is a trend towards an increased geographical reach of pulp supply chains that support the assessment of high risk of carbon leakage of the sector.

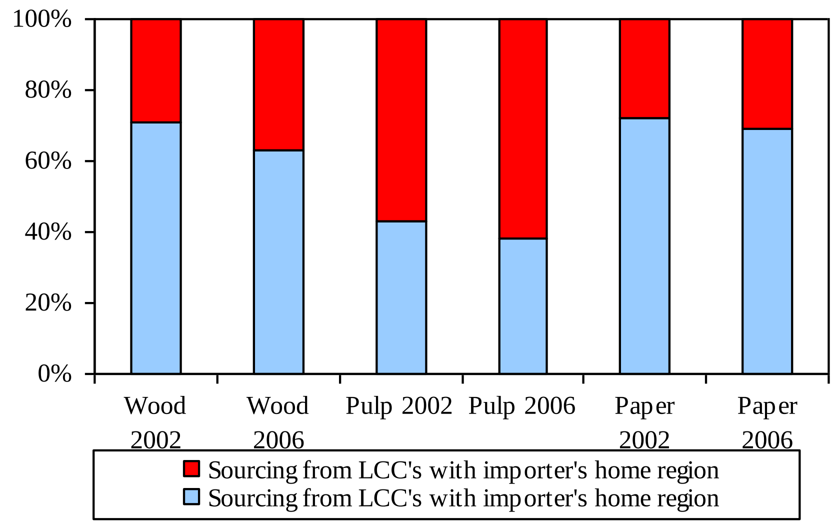
Regional supply chains play a greater role in wood and paper than in pulp. In all products, there is a trend towards an increased geographical reach of supply chains since 2002.

The leading low-cost source country for wood, pulp and paper products is China, with a world export share of 5.3 percent in 2006, followed by Brazil (3.9), Indonesia (3.3), Russia (2.5), and Malaysia (2.1).

Abatement potential

About 50% of the energy used in the European paper and pulp industry is based on biomass, almost 40% is based on natural gas and the rest is fuel oil and coal (2005). The use of biomass increases steadily every year. Therefore there is not a large scope for improvement on fuel substitutability.

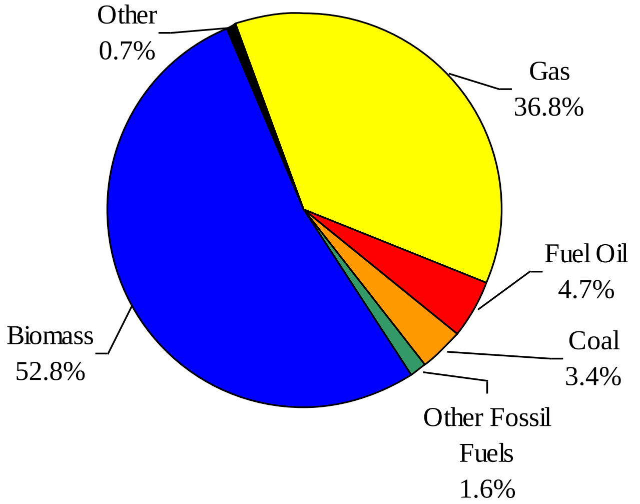
CHART 2.5: GEOGRAPHIC REACH OF LCC SOURCING BY PRODUCT GROUP



Source(s) : CEPI 2009.

[12] www.global-Production.com

CHART 2.6: SHARE OF ENERGY CARRIERS IN THE CEPI COUNTRIES' PULP AND PAPER INDUSTRY 2007



Source(s) : CEPI 2009.

2.8 Deep-dives for selected sectors which were identified as being at risk by The Commission

In addition to the template deep dive, sector level analysis has been undertaken for the ten sectors chosen by DECC (also, for further assessment of degree of leakage through econometric estimation, see Chapter 4). These sectors were chosen after deliberation by DECC. These sectors are often less explored and, in aggregate, offer insights into the different manufacturing processes covered by the EU ETS. Again, these deep dives have used the refined final set of assessment criteria, as listed in Chapter 3 as the basis for the sector exploration but the analysis is limited by the information that is available in the public domain.

These sectors have to date received relatively less analytical attention than some of the other energy and emissions intensive sectors covered by the EU ETS. The sectors chosen are a combination of both some of those identified as being at risk and those not at risk of carbon leakage in The Commission's assessment.

Of these ten sectors, those that are identified as being at risk by the Commission are:

- manufacture of other inorganic basic chemicals NACE 2413
- manufacture of plastics in primary forms NACE 2416
- manufacture of flat glass NACE 2611
- manufacture of lime NACE 2652
- manufacture of agricultural tractors NACE 2931

Manufacture of Other Inorganic Basic Chemicals NACE code 2413

BOX 2.2: MANUFACTURE OF OTHER INORGANIC BASIC CHEMICALS, INDUSTRY SUMMARY

- **EC Criteria:** Cost/GVA% is 11.9%, Trade Intensity is 31.7%.
- **Third largest basic chemical subsector**: 7.9% of chemical GVA & 13% of employment
- **Demand reliant on downstream sectors**
- **High product diversification**
- **Trade deficit in recent years** and worsening trade balance with falling exports and prices.

Source(s) : Climate Strategies and Eurostat.

Inorganic basic chemicals are compounds which come from naturally occurring minerals. They are distinguished from other subsectors in the basic chemical sector as they do not contain carbon. The sector covers a number of products which can be found on the PRODCOM database. These products are produced in large volumes demanded by both the chemical industry itself and other downstream sectors. The chemical industry is often very highly integrated between all the basic chemical subsectors because of the many steps in the production processes and the sheer volume of products that can be derived from compounds. There is therefore a high level of interdependence between production activities in all basic chemical subsectors and exposure to carbon pricing in one chemical subsector could impact on derivatives in another. Basic inorganic chemicals, and other chemical subsectors, benefit from large economies of scale.

The manufacture of 'other inorganic basic chemicals' is one of seven subsectors in the manufacture of basic chemicals[13]. It shares a number of similar characteristics to other basic chemical subsectors; it is dominated by large enterprises and involves an upstream, capital-intensive production process to create compounds which are used as inputs in to a number of modern-day manufacturing processes. According to the latest revisions to PRODCOM[14] (2007) 107 products are produced in the inorganic basic chemicals sector.

Cost structures

According to The Commission's assessment, the sector's combined direct and indirect) carbon costs increase as a percentage of GVA is 11.9%. A 2004 report by the Carbon Trust identified carbon costs in the basic inorganic chemicals sector to be closer to 5% of GVA but recognised that it was still plausibly at risk of carbon leakage.

Transport costs are high in the sector when chemicals are hazardous as they will require investment in vehicles. This impedes the transport of some basic inorganic chemicals over long distances. It is however very difficult to make generalisations about the sector because of the high level of product differentiation.

Generally speaking, production costs in the sector are determined by the access and price of: raw materials, energy supply and economies of scale.

Pass-through ability

The production growth rate is slowest relative to all of the seven basic chemical subsectors. Although the basic chemical sector experienced a trade surplus of 42.5 billion in 2009, the basic inorganic chemicals sector experienced a deficit. Imports in this subsector doubled between the years 2000-2007, with an annual increase of around 11%.

The prices of basic inorganic chemicals also fell by 15.6% between the years 2009-2010 whilst the chemical sector as a whole experienced a rise in price of 1.4%. In 2007, the basic chemicals sector represented around 8% of total value added in the chemicals sector but given these worsening trade conditions, this is likely to have fallen since then.

The European inorganic basic chemical sector may be able to pass through some carbon costs as regions that are relatively specialised in this sector may enjoy natural cost advantages and economies of scale. However, the ability to increase product prices would be limited by increasing competition overseas.

Abatement potential

Aside from changing the fuel mix, specific chemical products may have technical abatement potential that needs to be explored. Two products that are important feedstocks for the production of other chemicals are chlorine and caustic soda. These are made in chlor-alkali plants. Chlorine is a particularly important chemical and used in products such as pvc, paints and pharmaceuticals. Estimates by Eurochlor estimate 55% of all chemical processing in the European chemical industry rely on chlorine.

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[13] http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

[14] Prodcom is a survey on Products of the European COMmunity which details the products produced by manufacturing subsectors of the economy at an 8-digit level; 1 to 4 digits refer to the NACE classification in which producing enterprise is normally classified.

The production of chlor-alkali is energy intensive and so, depending on the fuel source, would be impacted by carbon costs.

Abatement potential in chlor-alkali plants principally comes from energy efficiency improvements. Reductions in power consumption per unit of output can be achieved by using more membrane cell technology, shifting away from mercury cell technology which generates hazardous wastes and is less energy efficient. There is a planned industry-wide shift towards membrane cell technology by 2020 in Europe. Other abatement options listed by Eurochlor have all focused on the reduced use of mercury which of course would have additional environmental benefits beyond reduced emissions.

Manufacture of Plastics in Primary Form NACE code 2416

BOX 2.3: MANUFACTURE OF PLASTICS IN PRIMARY FORM, INDUSTRY SUMMARY

- **EC Criteria:** Cost/GVA% is 3.0%, Trade Intensity is 27.1%. A qualitative assessment of the sector by The Commission concluded it was at risk.
- **Large basic chemical subsector**: 31% of chemical GVA & 43.6% of employment
- **Transport costs low** relative to product value
- **Demand reliant on downstream sectors**, including packaging & construction. Demand fell by 7.5% in 2008 because of the economic downturn.
- **Low levels of product differentiation**. Installations compete on price
- **Trade surplus** of €13bn in 2008. Main exporter is Belgium. By 2015, 90% of imports from the Middle East. In some countries, feedstocks are subsidised.
- Opportunities to reduce emissions by increasing **energy efficiency is limited**

Source(s): Climate Strategies and Eurostat.

The manufacture of plastics in primary forms is one of 7 subsectors[15] in the basic chemicals sector. In 2004, 94.1% of plastics in primary forms were produced by polymers. Polymers are compounds formed by the reaction of simple molecules (monomers). Primary forms are defined as “liquids and pastes, lumps, powders, granules, flakes and similar bulk forms[16]. These plastics in primary forms are then used in a number of downstream activities across a range of sectors and industrial activities including: textiles, packaging, automotive, electric and electronic, and household appliances, building and construction and industrial application[17]. The polymer derivatives of these monomers may also be categorised under a different subsector in basic organic chemicals and so, similar to the basic inorganic chemicals subsector, the interaction integration between downstream and upstream and downstream products and processes means that carbon costs in one subsector could impact on a number of basic chemical subsectors. The exact downstream use is determined by the grade of the plastic. There are approximately 20 groups of plastics

[15] These are the manufacture of industrial gases, manufacture of dyes and pigments, manufacture of other inorganic basic chemicals, manufacture of other organic basic chemicals, manufacture of fertilisers and nitrogen compounds, manufacture of plastics in primary forms, manufacture of synthetic rubber in primary forms.

[16] http://www.businesslink.gov.uk accessed 22/04/2010.

[17] PlasticsEurope (2009) The Compelling Facts About Plastics 2009.

produced in the manufacture of plastics in primary forms but 5 high volume groups: polyethylene, polypropylene (PP), polyvinylchloride (PVC), polystyrene and polyethylene terephthalate (PET) account for around 75% of plastics production in primary forms in Europe.

Cost structures

According to The Commission's top-down analysis the sector's combined direct and indirect carbon costs increase as a percentage of GVA is 3.0%. Additional research organised by the industry, verified by Arthur D Little consultants, using a bottom-up measurement found that carbon costs per GVA in this sector were actually closer to 5%. Additional qualitative analysis of the sector was undertaken by The Commission to accompany the quantitative estimates and this analysis concluded that the sector was at risk of leakage

A study by Eurostat[18] on the chemical sector in 2005 identified that the manufacture of plastics in primary form accounted for 31% of the total value added in the manufacture of basic chemicals sector and 43.6% of employment suggesting its relative importance both within the chemical industry and in the European manufacturing sector more broadly.

The bulk of emissions in the sector originate from the conversion of monomers to polymers (indirect emissions). Between the years 1990-2004, industry-wide emissions intensity declined by 38.8%. Energy intensity of production in this subsector and in the basic chemical sector has however decreased over the past 20 years due to the introduction of integrated crackers

The Commission's assessment identified the sector's trade intensity with non-EU 27 countries to be at 27.1% for the years 2006-2007[19]. One likely contributory reason for this is that international transport costs are low in this sector relative to the product price which makes it profitable to trade products over large distances and operate in international markets.

Pass through ability

Profit margins in the manufacture of plastics in primary forms have been declining in recent years due to increased international competition. In a qualitative assessment of the sector by The Commission this decline in profits was partly attributed to a widening gap between Asian and European cash cost margins, which have been exacerbated by a fall in capital investments in Europe in recent years.

As mentioned previously, the demand for packaging in primary forms originates from a number of downstream sectors. Packaging is the highest source of demand (38%), followed by buildings and construction (21%), automotive (7%), electrical and electronic (6%) and other applications including medical and leisure (8%). The sector saw a fall in demand for its products following the economic downturn, the aforementioned high volume group of polymers saw demand fall by 7.5%, however, given the seemingly short term nature of the recession, this figure may not be representative of longer term trends in demand.

Plastics differ in terms of their quality. Different grades are used to determine the best choice for their application. However, they are essentially commodities which are traded in a global market and operate on price competition rather than product

[18] Eurostat (2008), Statistics in focus 58/2008, "The manufacture of Basic Chemicals".

[19] EC (2009)¸ Results of the assessments of sectors and sub-sectors based on the qualitative criteria set out Article 10a(17) of Directive 2003/87/EC

differentiation. The main difference between the sectors internationally is the production process rather than the final product. An example used in the Commission's qualitative assessment of the sector is that for the production of polyvinylchloride (PVC), China uses acetylene technology whilst Europe uses ethylene technologies. The former is a much more emissions intensive production process. If European installations moved production to China, global sector emissions would see an increase worse than in the case of normal carbon leakage.

In addition to the detrimental environmental impact, relocation of industrial production to extra-EU regions has a knock-on effect on downstream plastic processing activities as there is a high degree of vertical integration in the industry and so negative multiplier effects may be felt. Carbon leakage is therefore a concern from both an economic and environmental viewpoint.

The EU is a net exporter of plastics in primary forms and according to Plastics Europe, enjoyed a trade surplus of around €13bn in 2008[20]. Eurostat calculated this figure to be €5.8bn in 2007[21]. Europe's trade surplus has been steadily increasing since 2002. Export volumes in 2006 were €65,792m, only 26% of this was extra-EU trade and 74% was intra-EU27 trade. Europe's main exporter is Belgium and the main importers are the USA. The USA is the EU27's main trading partner for plastics, importing €2.7 bn worth of plastics from the EU in 2006.

The Commission calculates the trade intensity in the manufacturing of primary plastics sector as 27.1% but this is expected to exceed 30% in the near future, principally due to an anticipated higher influx of imports. In 2006, imports were worth €62,759m, 85% were intra-EU and 15% extra. Germany was the EU27's main importer. In the next few years (approximately by 2015), 90% of imports will come from the Middle East[22] and Europe's trade balance will worsen, but there is an underlying trend of growth in capacity in non-European countries which precedes the introduction of carbon costs.

A reason for this changing balance of trade is that competitors in emerging markets have enjoyed relatively favourable input costs. This may be in part due to natural advantages but favourable domestic policies outside of the EU may be supporting the growth of the plastics sector. One such example is that Saudi Arabia receives discounted prices for natural petroleum, a key feedstock for ethylene, whilst other regions are charged higher prices. Cost advantages may take the form of lower feedstock prices, process costs and low transport costs due to relatively close proximity to end use markets. Carbon pricing has the potential to exacerbate these cost differences.

It is likely that the European plastics in primary forms sector will find it increasingly difficult to pass through additional carbon costs to consumers over time as they face increased competition from extra-EU competitors with lower production costs in a market where the price of products is largely determined at the global level.

Abatement potential

The manufacture of plastics in primary forms subsector has, along with other subsectors of the chemicals industry, managed to decrease the energy intensity of production in recent years, thereby reducing the associated emissions. An assessment

[20] PlasticsEurope (2009) The Compelling Facts About Plastics 2009

[21] Eurostat (2008), Statistics in focus 58/2008, "The manufacture of Basic Chemicals".

[22] Eurostat (2008), Statistics in focus 58/2008, "The manufacture of Basic Chemicals".

by The Commission however, found that the remaining potential to increase energy efficiency is more limited[23] and no other technical abatement options were listed for the sector from sources in the public domain.

Manufacture of Flat Glass NACE code 2611

BOX 2.4: MANUFACTURE OF FLAT GLASS, INDUSTRY SUMMARY

- **EC Criteria:** Cost/GVA% is 8.0%, Trade Intensity is 21%.
- Energy intensive production process
- Represents 1/3 of production volumes in the glass sector but low employment as highly automated, emissions intensive process.
- **Transport costs are high,** representing 10-15% of total costs. Markets 200-600km
- Very concentrated EU market (4 firms dominate). Germany is the largest producer
- **EU capacity and output is constant** but increasing in some Eastern European & Middle Eastern countries. Trade surplus in 2004 became a deficit in 2007 of €143m
- Opportunities to **reduce emissions using recycled glass**
- **High sunk costs** and long investment horizons.
- Demand from downstream activities

Source(s) : Climate Strategies and Eurostat.

Cost Structure

There are 2 distinct types of flat glass production processes used in the EU; rolled glass (5%) and float glass (95%). Flat glass can be produced continuously for 24 hours a day. Typically 500 tonnes of flat glass can be produced every day which is almost double the glass sector's average of 300. Due to these high levels of output, in 2005, flat glass accounted for 1/3 of production volumes in the entire glass sector. Employment in the flat glass sector doesn't reflect the scale of output as the production process is largely automated. In 2008, the sector employed 16,000[24] people in Europe but there is no Eurostat data available to compare this trend over time.

Glass production is an energy intensive process, accounting for 20% of the total costs in the float process. The energy intensity of rolled glass is 32% higher compared with float glass as it uses smaller furnaces with lower loads which are less efficient and more emissions intensive. It is however produced on a much smaller scale than float glass and so in aggregate it contributes less to emissions in the sector.

Emissions from the flat glass sector were around 7mill t/CO_2 in 2008 (6.5 from float glass and 0.5 mill from rolled glass. This is approximately equal to 0.50-0.8tCO_2 per tonne of flat glass[25]. The Commission's assessment identified that indirect and direct

[23] EC (2009), Results of the assessments of sectors and sub-sectors based on the qualitative criteria set out Article 10a(17) of Directive 2003/87/EC

[24] ECORYS (2008), FWC Sector Competitiveness Studies – Competitiveness of the Glass Sector

[25] GHK(2007), Energy efficiency and use of low carbon technologies in energy intensive industries (EII) in the European Union and in the rest of the world

carbon costs as a percentage of the sector's GVA totalled 8.0% (6.2 and 1.8% respectively).

Transport costs are high in the flat glass subsector, usually representing around 10-15% of total costs[26] largely because of its bulky and heavy shape which reduces the financial viability of trade over long distances. Produce is supplied on a local or regional basis. Analysis by GHK identified an average distance of 200k for transport and 600km as the economic limit for the glass sector in its entirety. Given flat glass's heavy and bulky shape, it can be assumed that this subsector has a market in the smaller range of GHK's analysis.

Pass through ability

Flat glass production in Europe has remained fairly constant between the years 2000-2007 with no major capacity expansion in the sector during this time. The market is very concentrated in the EU and is dominated by 4 large multinational firms: NSG (Pilkington), Saint-Gobain, Asahi (Glaverbel) and Guardian. Germany is the largest producer of flat glass, followed by Poland and the Czech Republic[27].

The main sources of downstream demand for flat glass are from the construction and automotive industry which have seen outputs fall significantly in light of the recent economic downturn. It is likely that flat glass will be the most exposed glass subsector to the economic downturn because of the high dependence on demand from pro-cyclical downstream sectors such as housing[28]. This downward trend in demand is expected to reverse in the longer term.

There is not a high degree of product differentiation in the market. Although there is flexibility in the production process to change the thickness, flat glass is essentially a commodity. European producers can mark their flat glass with a "Made in Europe" mark to distinguish their products on the basis of quality but there is no guarantee that this will lead to a preference for domestic rather than foreign produce.

The Commission calculated the trade intensity of flat glass to be 21%. In 2004, the sector enjoyed a trade surplus of 445,000 tonnes of flat glass which became a trade deficit of 358,000 tonnes in 2007; equivalent to approximately €143m. In contrast to the EU's relatively constant capacity and output in the flat glass sector, extra-EU countries, namely: Russia, Ukraine, Belarus, Qatar, UAE and Egypt have all increased capacity in the past 5 years and are continuing to do so. Although transport costs are high for the flat glass sector, these countries are in close enough proximity to form part of a regional flat glass market and so are a major challenger to the EU flat glass sector[29] and have eroded their market share.

Given the likely price competition, homogeneity of produce and increasing competition from expanding extra-EU capacity, carbon cost pass through ability is likely to be low.

Abatement potential

Since the 1960s, the flat glass sector has managed to reduce energy consumption in production on an average of 1.5% per annum but this rate of reduction is slowing as marginal reductions in energy intensity become more technically difficult. Instead,

[26] GHK(2007), Energy efficiency and use of low carbon technologies in energy intensive industries (EII) in the European Union and in the rest of the world

[27] ECORYS (2008), FWC Sector Competitiveness Studies – Competitiveness of the Glass Sector

[28] ECORYS (2008), FWC Sector Competitiveness Studies – Competitiveness of the Glass Sector

[29] ECORYS (2008), FWC Sector Competitiveness Studies – Competitiveness of the Glass Sector

the flat glass sector could increase the rate at which it uses recycled glass as this requires 25% less energy per tonne of flat glass produced relative to virgin raw material. This however will be limited by physical availability[30].

Investment in the flat glass sector is very lumpy. A float glass plant typically costs €65-140mill[31] to build (depending on size, location and complexity of the product). Once in operation, a furnace will operate for 24hours a day for 12-15 years. After this, the plant will either be rebuilt or undergo repair work which would cost in the region of €30-50mill[32]. These high upfront capital investment (sunk) costs which commit producers to a particular location for more than a decade mean that the decision to relocate is unlikely to be based on carbon cost differentials alone. The multinational firms operating in the EU may however choose to increase production levels in extra-EU plants.

Regulatory and legal framework

The main source of regulation in the flat glass sectors is on downstream products, in particular the construction industry. For example regulation, which requires more energy efficient building products, may require changes in the end product and therefore the production process of flat glass may need to adapt in order to comply with end user demands.

Manufacture of Lime NACE code 2652

BOX 2.5: MANUFACTURE OF LIME, INDUSTRY SUMMARY

- **EC Criteria:** Cost/GVA% is 6**5.2%,** Trade Intensity is 2.6%.
- Crucial input for a number of downstream sectors, **few substitutes**
- **Extremely emissions intensive** sector. 1.3% of total covered by EU ETS. Energy costs (€23.8/t) represent a third of selling price of lime (€70/t).
- **Carbon costs** are anticipated to be **very high** relative to the sector's **small profit margins.**
- Capital intensive production with long investment schedules & high sunk costs.
- Emissions are intrinsic to the conversion process so technical abatement is low.

Source(s) : Climate Strategies and Eurostat.

The European lime sector is relatively small in terms of its contribution to GVA but is a crucial input for a number of downstream sectors. The main consumers of lime are: the steel industry (40%), agriculture and environmental sector (20%), construction sector (20%), sugar industry (5%) and the pulp and paper industry (2%)[33].

Cost Structure

Even though the lime sector is small in terms of its contribution to EU GDP, it represents 1.3% of the total emissions covered by the EU ETS[34]. Emissions in 2007

[30] GHK(2007), Energy efficiency and use of low carbon technologies in energy intensive industries (EII) in the European Union and in the rest of the world

[31] GHK(2007), Energy efficiency and use of low carbon technologies in energy intensive industries (EII) in the European Union and in the rest of the world

[32] ECORYS (2008), FWC Sector Competitiveness Studies – Competitiveness of the Glass Sector

[33] European Commission, DG Economic and Financial Affairs (2007), Imposing a unilateral carbon constraint on European energy-intensive industries and its impact on their international competitiveness – data and analysis.

[34] European Lime Association (2008), EULA position paper on the Review of the EU ETS

were 28,563kt CO_2[35], the largest sources of production were in Germany, Belgium and France. The creation of lime involves a very capital, energy and emissions intensive production process. The exact energy intensity and associated combustion emissions of production is determined by the type of kiln used in the production process. Limestone is converted in to lime via calcination i.e. calcium carbonate is burnt in a kiln at very high temperatures (between 900 and 1200 degrees Celsius). In addition to combustion related emissions, the chemical reaction for calcination has a fixed emissions rate of 0.785tCO_2 per tonne of lime[36]. The calcination part of the production process accounts for 70% of sector emissions whilst the remaining 30% originates from fuel combustion[37]. Emissions are therefore very high per unit of output produced[38].

Due to the high temperatures required in the kilns, energy costs are high for the lime sector at €23.8/t. This is a third of the selling price of a tonne of lime (€70 on average). The Commission's quantitative assessment calculates the combined indirect and direct carbon cost increase as a percentage of the sector's GVA as 65.2%, the highest out of all of the sectors analysed in this study.

A number of studies have analysed the potential cost increase for the lime sector. The analyses differ depending on allocation methodology and assumptions on the carbon price. The European Lime Association assumed a €30/t CO_2 carbon price and calculated a 40-45% price rise[39]. This is broadly in line with the analysis in a 2007 study by The Commission[40] who calculates that for a cost of €20/t CO_2, the incremental cost increase will be €22 per tonne of lime (approximately a 30% increase if the current price per tonne is €70). The Carbon Trust[41], based on analysis undertaken by Climate Strategies calculate that with a price of €20/t CO_2, the price of lime would increase by around 60% under 100% auctioning and 0% under 100% free allocation. They calculated the maximum value at stake to be 126%.

Pass through ability

Partly due to the high energy costs, the sector operates with small profit margins. The total annual turnover in the lime sector is €2.5bn. Analysis by the European Lime Association calculated that the potential increase in production costs from CO_2 pricing is more than 3 times the profit margins of EU producers[42].

The supply of lime is very concentrated in Europe. Installations mainly operate in 6 European countries. The largest number of kilns are in Germany (168), followed by Italy (70), Spain (50), France (50) Poland (45) and Belgium (40)[43]. There are approximately 100 companies and 200 plants, mainly SMEs, in operation[44].

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[35] Ecofys.

[36] Ecofys.

[37] NERA (2008),Potential impacts of the EU ETS on the European Lime Industry

[38] NERA (2008),Potential impacts of the EU ETS on the European Lime Industry

[39] European Lime Association (2008), EULA position paper on the Review of the EU ETS

[40] European Commission, DG Economic and Financial Affairs (2007), Imposing a unilateral carbon constraint on European energy-intensive industries and its impact on their international competitiveness – data and analysis.

[41] CS dynamics and differentiation

[42] European Lime Association (2008), EULA position paper on the Review of the EU ETS

[43] Ecofys

[44] European Lime Association (2008), EULA position paper on the Review of the EU ETS

The Commission's analysis calculated the trade intensity of the lime sector to be low at 2.6%. Data for 2006 shows that it still enjoyed at trade surplus of 2.3% of annual turnover but this has fallen from 6% in 2000[45].

It is likely that given the high emissions intensity of production, carbon cost differentials could greatly exacerbate this worsening trade balance and the ability of firms to pass through carbon costs will be low.

Abatement potential

Given the capital intensity of the lime production process, investment schedules are likely to be long and sunk costs, high. The emissions inherent in the limestone conversion process mean that the technical potential to reduce emissions in the sector is limited short of reducing output[46].

Manufacture of Agricultural Tractors NACE code 2931

There was insufficient information available in the public domain to provide a comprehensive qualitative overview of this sector.

[45] Ecofys

[46] European Lime Association (2008), EULA position paper on the Review of the EU ETS

2.9 Deep-dives for sectors which were not identified as at risk by The Commission

Of the ten sectors identified by DECC, those which were close to but did not exceed the various assessment thresholds set out in the Directive (as outlined in Chapter 3) or were qualitatively assessed and deemed not to be at risk of carbon leakage are:

- manufacture of glass fibres NACE 2614[47]
- manufacture of bricks, tiles and construction products NACE 2640
- casting of steel NACE 2752
- manufacture of motor vehicles NACE 3410
- manufacture of plaster products for construction purposes NACE 2662

Manufacture of Glass Fibres NACE code 2614

BOX 2.6: MANUFACTURE OF GLASS FIBRES, INDUSTRY SUMMARY

- **EC Criteria:** Cost/GVA% is 3.6%, Trade Intensity is 23.4%.
- Used in a number of downstream activities for insulation or reinforcement.
- Represented **8%** of the **glass sector's total output,** employment is around 8,200
- **Most energy & emissions** intensive glass subsector, but emissions are small in absolute terms. **GVA is very high.**
- Lumpy investment schedule with high sunk costs over a long time horizon.
- **Transport costs are low** & the product is fairly homogenous. Price competition.
- The **trade balance fluctuates** between a surplus and deficit between years. Germany has the largest output. The European market is **dominated by 7 firms** which account for 20-25% of global production. The USA produces 50% of global glass fibres
- EU demand driven by retrofit legislation for housing.

Source(s) : Climate Strategies and Eurostat.

Glass fibres are either manufactured to be used as reinforcement fibres or insulation fibres. Both types of glass fibres have a number of industrial applications. Reinforcement fibres are used by the building, automotive and transport industry as well as the electrical and electronics industry (often optic fibres). Insulation fibres are mainly used in buildings for thermal insulation, heating and ventilation applications, industrial applications, fire protection and also for acoustics. The main consumers are in the construction industry.

Glass fibres are most often produced using a float method similar to that used in the flat glass sector. They represent 8% of the glass sector's total production which was approximately 3Mt in 2007, employing approximately 8,200 people[48] in Europe

[47] At a NACE 4 digit level of disaggregation Manufacture of Glass Fibre (2614) was not found to be at risk of carbon leakage. However, further analysis carried out by The Commission suggests that one subsector "Manufacture of Continuous Filament Glass Fibres" could be at risk. See; http://ec.europa.eu/environment/climat/emission/pdf/proportionate_ia_%20leakage_list16sep.pdf

[48] ECORYS (2008), FWC Sector Competitiveness Studies – Competitiveness of the Glass Sector

Cost structure

The Commission identified the direct and indirect carbon costs relative to the sector's GVA to be 3.6%[49]. A reason for this may be the sectors high GVA to mass ratio rather than having low carbon cost impacts. The glass fibre production process is the most energy intensive out of all of the 5 glass subsectors: 17 Gt of energy is used to produce 1 tonne of glass and the corresponding calculations regarding emissions intensity of production are therefore also the highest out of all the subsectors at 0.8-1t CO_2/t of glass, even if in absolute terms this subsector is not the largest contributor to emissions. Therefore the cost/GVA ratio does not provide adequate insights into the emissions profile of the sector

Similar to the flat glass subsector, the glass fibre subsector also has a lumpy investment schedule. Once built, furnaces operate continuously for 24 hours a day. The investment requirements of a plant are dependent on the type of furnace used, eg a recuperative furnace can operate for 8-12 years, whilst an electrical furnace can operate for 3-6 years. As such there is limited flexibility to relocate production in the short run.

Production of flat glass has remained largely constant between the years 2000-2007; the latest new plant to be built was in 1998 for €45m. Analysis by FWC in 2008 estimated that the rebuild of a furnace would cost €8m and a newly built medium sized plant would cost €75-90m. Again, carbon costs would likely be one of a number of production location factors for a glass fibre manufacturer in Europe looking to invest in new capital, given the scale of financial and time commitment required.

Pass through ability

Partly due to low transportation costs and the relatively high added value per tonne of product, the glass fibre subsector has faced increasing extra- EU competition which has dampened profit levels in the sector in Europe. The products themselves are relatively homogeneous and so producers compete on price. European products are distinguished by the mark "Made in Europe" but it is not clear how this recognition of quality will affect consumer's marginal willingness to pay for products originating from the EU, relative to those from abroad. This means that cost structures become very important for producers as pass through ability is limited. In recent years, the European glass fibres sector has downsized and streamlined production practices in a bid to become more competitive[50].

The European market is dominated by seven large firms which account for 20-25% of total world production. Trade intensity was calculated to be 23.4% in The Commission's study. A potential reason for this high level of international trade is the fact that transport costs are low relative to the value added of the sector and so goods are cheaply and easily transportable over long distances. The trade balance fluctuates between a deficit and a surplus. Reinforcement fibres are more internationally traded, only 5% of insulation fibres are exported to extra-EU regions. Exports in the glass fibre subsector represented 7% of all glass exports in 2005[51]. Germany is the largest producer in Europe and the USA is the largest producer in the world, accounting for 50% of global glass fibre production. As a result, the USA is the largest source of imports in to the Europe. The value of imports has fallen between 2004-2007 from

[49] EC (2009)¸ Results of the assessments of sectors and sub-sectors based on the qualitative criteria set out Article 10a(17) of Directive 2003/87/EC

[50] ECORYS (2008), FWC Sector Competitiveness Studies – Competitiveness of the Glass Sector

[51] GHK(2007), Energy efficiency and use of low carbon technologies in energy intensive industries (EII) in the European Union and in the rest of the world

€1,685 to €1,583 per tonne of glass fibre imported but increased in absolute amounts. Conversely, the value of imports has increased over the same period by 22% so although the level of imports have increased, the negative impact on the trade balance in the EU is lower than it could have been because of the favourable change in value of exports and imports.

Demand growth for fibres from within the EU has been partly driven by European retrofit legislation which aims to increase the energy efficiency of housing which, in turn, would reduce the energy consumption and emissions from the housing sector of the economy.

The products are highly differentiated and heavy to transport which create non-price barriers to competition. This means that some cost pass-through is likely.

Abatement potential

A source of potential abatement is the increased use of recycled glass. Relative to virgin glass, it uses 25% less energy per tonne of output produced. No further information was available in the public domain about other technical abatement opportunities in this sector.

Manufacture of Bricks, Tiles and Construction Products NACE code 2640

BOX 2.7: MANUFACTURE OF BRICKS, TILES, AND CONSTRUCTION PRODUCTS, INDUSTRY SUMMARY

- **EC Criteria:** Cost/GVA is 9.8%, Trade Intensity is 2.7%. Qualitative assessment was needed because of recent redefinition of the sector & sparse data.
- Number of small kilns in the sector not covered by the EU ETS
- **High proportion** of the ceramic sector's **value added** (60.4% in 2006) and **employment** (51% in 2006).
- **High transport costs** relative to GVA per tonne. Mainly **regional markets.**
- **Increasing product differentiation**, the EU marks high quality products.
- Falling emissions & energy intensity per unit of production over the past decade.
- Sector needs to comply with international regulation in downstream sectors.

Source(s) : Climate Strategies and Eurostat.

The manufacture of bricks, tiles and construction products is a subsector of the European ceramics industry. In 2009, the NACE definition of the sector was revised and so the analysis of the sector over time is inconsistent. This was a key reason as to why The Commission decided to introduce an additional qualitative assessment to determine the risk of leakage.

The production process for bricks, tiles and construction products involves a number of stages. First clay is extracted, and then prepared via crushing and stockpiling and varying the moisture content. For bricks, the clay is moulded, cut in to shape, dried and then fired in a kiln. Energy costs currently represent an average of 30% of production costs[52] in the clay building materials subsector and account for approximately half the energy consumed in the ceramics industry as a whole[53].

Cost structures

The Commission calculated the combined direct and indirect carbon costs to be 9.8% of the sector's GVA (8.0% and 1.8% respectively). CO_2 emissions arise from the raw materials themselves during the firing process in the kiln and also from combustion emissions used to heat the kiln. This data uses different sector boundaries relative to the new NACE revisions. Originally, this subsector was partially defined as "clay building materials" subsector. In addition to this change in sector definition, the data available for The Commission's assessment were sparse and so calculations did not accurately reflect the CO_2 emissions profile for the entire sector. Community Independent Transaction Log (CITL) data was used but only listed emissions for 20 installations when in fact 200 installations are covered by the EU ETS. In addition to these accounting issues, a number of the smaller ceramics manufacturing installations are not covered by the EU ETS because annual emissions are below 25kt/CO_2. In some European countries this represents a significant proportion of the total number of installations in operation in the manufacture of bricks, tiles and construction products. In Spain, 90% of brick and tile manufacturing installations emit less then 25kt/CO_2 and this figure is approximately 60% in France[54].

Analysis by Ceramie Unie[55] identified that, of all the 6 subsectors in the European ceramics industry, clay building materials accounted for 60.4% of the total sector value added in 2006, approximately equal to €23.5bn. In addition, it accounted for 51% of the ceramics industry's employment; approximately 165,000 people in 2006. Given its industry significance under the previous subsector definition and the statistical weakness of the quantitative analysis, understanding more qualitative characteristics of the sector are key in determining the risk of leakage.

Pass-through ability

The markets in the North of Europe are mainly larger producers whilst the Southern countries tend to be more characterised by small and medium enterprises[56]. The main brick producing countries are Italy and Germany, while France has a large roof tile industry.

Trade intensity in the sector is estimated to be 2.7% by The Commission's assessment but for reasons explained above; this figure may not be entirely representative because of limited data. However, it is reasonable to expect that trade intensity is low in this sector because of high transport costs relative to the GVA per tonne of product and that markets tend to be regional[57].

Products in the sector may be sufficiently highly differentiated from international competitors to shield it from high levels of market penetration should carbon costs increase European cost schedules significantly. The EU is increasingly standardising

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[52] http://www.cerameunie.eu/members.html accessed 22/04/2010

[53] EC (2009)¸ Results of the assessments of sectors and sub-sectors based on the qualitative criteria set out Article 10a(17) of Directive 2003/87/EC

[54] Ecofys

[55] http://www.cerameunie.eu/members.html accessed 22/04/2010

[56] EC (2009)¸ Results of the assessments of sectors and sub-sectors based on the qualitative criteria set out Article 10a(17) of Directive 2003/87/EC

[57] EC (2009)¸ Results of the assessments of sectors and sub-sectors based on the qualitative criteria set out Article 10a(17) of Directive 2003/87/EC

products and recognises high quality European produced goods with a 'CE' mark of conformity. Given these coordination efforts, the sector is unlikely to compete on price alone and so the willingness to substitute between international and domestic goods (Armington elasticity) is expected to be low.

Competition may however come from other industries which produce non-clay substitutes for the construction sector such as concrete, steel and timber. However, these sectors would also be covered by the EU ETS and so the degree of competition with the manufacture of bricks, tiles and construction products will be dependent on the relative cost impact from carbon pricing for these other sectors.

Given the incomplete information available on this sector, it is difficult to determine the ability of firms to pass through additional carbon costs. High transport costs are likely to preserve regional pricing strategies and so some cost pass-through can be expected in inland regions of Europe.

Abatement potential

The ceramics industry has in fact made significant improvements in the energy efficiency of production in the past decade, halving energy use. The emissions intensity of production has also fallen as the sector shifted towards the use of natural gas. Industry-led initiatives to reduce the energy consumption per unit of output have been untaken for the past few decades. For example, the energy consumption for 1t of wall and floor tiles has been reduced by 47%[58] between the years 1980-2003. This may in part be due to rising energy costs but generally demonstrates industry responsiveness to market incentives although it was not possible to locate information on new technical abatement opportunities in the sector. Another example of industry led abatement initiatives is the widespread switch to the use of natural gas for drying and firing operations in kilns which rose to 90% in 2001 away from coal[59].

Regulatory and legal framework

The manufacture of bricks, tiles and construction products face a number of regulatory and technical barriers to trade in different regions. For example, import tariffs on ceramic tiles have been levied by the US on all imports and compulsory certification of construction products is required in several Eastern European countries[60].

Manufacture of Motor Vehicles NACE code 3410

BOX 2.8: MANUFACTURE OF MOTOR VEHICLES, INDUSTRY SUMMARY

- **EC Criteria:** Cost/GVA% is 0.5%, Trade Intensity is 28.9%.
- 95% of sector output in car production which has **high product differentiation**.
- **Very high employment** (6.5% of total EU manufacturing) concentrated in Germany, France, UK, Spain & Italy. The EU is the world's largest producer.
- **High investment in research & development** for production & product.
- **Demand sensitive to the economy**. Fell in recent years but high in longer term as countries develop & seek increased mobility. Growing demand in China & Russia.
- Producers face different product regulation depending on the export destination.

Source(s) : Climate Strategies and Eurostat.

[58] Ecofys

[59] European Commission qualitative assessment

[60] Ceramie Unie

There are 15 international companies involved in the European manufacture of motor vehicles: BMW Group, DAF Trucks, Daimler, FIAT Group, Ford of Europe, General Motors Europe, Honda, Jaguar Land Rover, MAN Nutzfahrzeuge, Nissan, Porsche, PSA Peugeot Citroën, Renault, Scania, Toyota Motor Europe, Volkswagen and Volvo Group. In 2009, approximately 91.5% of the sector's output was from car production, vans smaller than 3.5t represented 6.7% of output, trucks larger than 3.5t were 1.6% and buses represented 0.2% of output. Employment in the manufacture of motor vehicles is high in Europe at 2.2mill which represents 6.5% of total EU manufacturing. Production is concentrated in Germany, France, the UK, Italy and Spain.

According to The Commission's analysis the sector's combined direct and indirect carbon costs increase as a percentage of GVA is 0.5% (0.2% and 0.4% respectively). Trade intensity was calculated to be 28.9%, this is just under the threshold for Article 10a(16) of Directive 2003/87/EC which identifies a sector as being at risk if trade intensity is more than 30% of GVA. The production of motor vehicles is an example of a complex manufacturing process.

Cost structures

Between the years 2005-2007, emissions have increased in absolute terms by 1.4% but decreased by 5% per CO_2 of unit produced. This may in part be due to a fall in energy consumption (6.5% in terms of energy per unit produced and 0.9% in terms of total energy consumed) during this time but vehicle production volumes have increased.

Pass through ability

The European manufacture of motor vehicles sector produces high quality products which are differentiated in terms of technical detail and branding. Upstream inputs include metals, chemicals, plastics, textiles and electric and electronic systems These inputs that are covered by the scheme may choose to pass through their carbon costs to downstream sectors such as the manufacture of motor vehicles and the cumulative impact of this needs to be considered.

Given the levels of R&D expenditure and high rates of innovation to reflect new government policies and changing consumer tastes, parts of the workforce are very highly skilled.

Demand is very pro-cyclical and so the demand for all vehicles manufactured by the sector fell in 2008. The decline in demand varied across EU member states but on average, car sales declined by 19.3% in 2008 and demand for all other vehicles produced in the sectors also fell. This trend continued in to the first quarter of 2009. More information regarding the short term impact of the economic downturn on demand for motor vehicles should emerge. In the longer term, demand for personal mobility is expected to continue to grow as an increasing number of the global population enjoy higher incomes and standard of living, particularly in emerging economies

The EU is the world's largest vehicle producer and enjoys a net trade surplus of over €40bn p.a. The principle destinations for exports are the USA, Switzerland, Japan and Turkey and there is growing demand from China and Russia. Exports are valued at €70bn annually. Imports principally come from Japan, Turkey, South Korea and the USA and rising in India and China. Although individuals are loyal to brands and models, the location of the production is made less obvious to the consumer and vehicle components are often made across the globe and shipped for final construction

The EU's strong market position and the sector's high degree of product differentiation means that the manufacture of motor vehicles subsector would be able to pass on a percentage of carbon costs to consumers.

Abatement potential

European manufacturers of motor vehicles have already introduced a number of energy efficiency initiatives into the production process that would reduce their associated emissions. These have included: smaller production lines (line compacting), optimising the operation of combustion plants e.g. by using best available technologies, substitution of fuels from high carbon to low carbon and in some instances, the development of co-generation. The impact of these initiatives on energy use and the associated emissions have however been limited by the increased use of air treatment in painting shops and the introduction of water-based paint. Both of these processes require additional energy. The net impact on energy and emissions is therefore unclear. The sector has suggested that additional opportunities to reduce CO_2 on a large scale at a low cost would be difficult.

Regulatory and legal framework

European manufacturers of motor vehicles have to comply with a myriad of safety and technical regulations which differ depending on the location of the exported vehicle[61]. In addition to these regulations relating to product design, there is a risk that the WTO's draft text on modalities for Non-Agricultural Market Access (NAMAs) will penalise exports of motor vehicles from the EU27. It currently permits developing countries to maintain import tariffs on European Automotive products. However, the EU also imposes similar import duties.

Casting of Steel NACE code 2752

BOX 2.9: CASTING OF STEEL, INDUSTRY SUMMARY

- **EC Criteria:** Cost/GVA% is 2.0%, Trade Intensity **is estimated** to be close to 10%
- **High degree of vertical integration** in the steel production process. Likely increased costs for end use if all subsectors face carbon costs.
- Capacity increase in the EU exceeded greatly by increase in **China**
- Emissions low relative to other processes in steel production but **difficult** to pinpoint the **exact impact** of the EU ETS on this subsector as there are a number of integrated steel plants in operation.

Source(s) : Climate Strategies and Eurostat.

Steel casting is a difficult subsector to characterise because it is often linked into the rest of the steel making process in an integrated steel plant. Subsequently, information for this specific subsector was difficult to acquire. The main sources of information were The Commission's qualitative assessment of the sector and the European Foundry Association.

Cost Structure

Between the years 1993-2004, ferrous foundries in Europe increased production by around 25% from 11 million to 13.5 million tonnes. During this same time period

[61] For a full description of regional policies affecting imports from the EU 's sector for the manufacture of motor vehicles, please see the European Automobile Industry Report 2009 which is available at the ACEA website.

China increased its capacity by 73% from 12 to 30 million tonnes; maintaining its dominant market position.

The Commission calculated the combined direct and indirect carbon cost increase as a percentage of the sector's GVA to be 2.0% (0.6 and 1.4% respectively). Emissions principally arise from combustion in furnaces to melt the steel. Foundries in steel castings mainly use electrical melting furnaces and so the energy intensity and associated emissions intensity is relatively lower than if combustion installations were used. Casting has relatively low emissions compared with other processes in the construction of steel.

Pass through ability

The Commission's assessment finds that there is moderate market concentration in the steel casting sector (mainly in Germany, with more than double the amount of output in the steel casting sector relative to the second largest producing country; France) and they calculate that profit margins are between 2.7-3.3% between the years 2005-2007. It is not clear however how they arrived at these figures and whether or not information on steel casting from integrated steel plants were factored in to this analysis.

Demand in the sector comes from downstream activities in construction, machinery and valve making who use steel as an input. Upstream inputs come from the manufacture of basic iron, steel and ferro-alloys which will also face increased carbon costs. The cumulative impacts of carbon costs along the production chain is likely to lead to an increase in costs for end users though the price elasticity of demand may be small because of the lack of steel substitutes.

The Commission decided to undertake a qualitative assessment of the sector because data limitations prevented the calculation of trade intensity of the sector. The available data indicated the trade intensity to be close to the 10% threshold but the representativeness of the analysis is questionable. Difficulties with data collection may again be in part due to the wider difficulties with the sector definition. Although casting is a distinct production process from the manufacture of steel, there is a high degree of vertical integration in the industry which makes it difficult to isolate the carbon cost impact on specific subsectors and processes.

More information on the level of steel casting that is undertaken in integrated steel plants relative to foundries is needed before assessing the carbon cost-pass through ability.

Abatement potential

Steel casting has relatively low emissions in comparison to other parts of the steel construction process as it simply involves melting and pouring of molten steel into casts.

Manufacture of Plaster Products for Construction Purposes NACE code 2662

There was insufficient information available in the public domain to provide a comprehensive qualitative overview of this sector.

2.10 Summary of Literature review

This comprehensive review has identified, we believe, a majority of the major studies related to carbon leakage. The key findings relevant to the study are:

- generally, there is a rapidly increasing body of literature addressing carbon leakage though definition and specification of models of causality is at a relatively early stage. There is a limited degree of time series data for econometric analysis. Nevertheless the studies provide access to a body of thought particularly relevant to this study though the insights require careful judgement in their application.
- there is additional literature, particularly from the international trade and competition fields, which could provide a relevant source of information due to a similarity in circumstances.
- the deep dives provide an understanding of sectors, offering broader perspectives and illustrating their similarities and differences. These sector discussions will complement the econometric analysis in later chapters.

3 Criteria to Assess Carbon Leakage

3.1 Development of the Criteria

Objectives

The key objective specified in the terms of reference guiding the development of criteria was:

- to identify the sectors at risk of carbon leakage, considering those criteria (increased production costs as a result of both direct and indirect emissions and trade intensity) that have already been used to inform existing analyses, and potentially other criteria which might provide additional detail on the risk of leakage

The methodology for risk assessment specified in the terms of reference and subsequent discussions with DECC proposed the identification of 10 sectors at NACE-4 level. These were sectors to be selected to inform the *process* of risk assessment, and were ***not*** the sectors at most risk. The intention was to select sectors at risk to different extents, including those with measures of production costs and trade intensity that bracketed the current thresholds proposed in the EU ETS Directive in order to be able to draw conclusions on those thresholds.

The Commission's criteria resulted in selection of 164 sectors

During 2009, The Commission developed and finalised a list of sectors at the NACE 4 level, deemed at risk of carbon leakage in Phase III of the EU ETS.

The Directive cites two criteria, trade intensity and additional CO_2 cost in relation to GVA, and three combinations of thresholds to determine sectors at risk. Sectors which exceeded any of these thresholds were listed as being at risk.

A sector meeting any one of the following thresholds in The Commission's assessment is deemed to be at risk of leakage:

- increase in production costs > 5% of GVA, and extra-EU trade intensity > 10%;
- increase in production costs > 30% of GVA
- extra-EU trade intensity > 30%

The production costs include potential increases in both direct and indirect costs. The extra-EU trade intensity is defined as (exports to non-EU + imports from non-EU) divided by (annual turnover + total imports).

These factors are calculated at €30/t carbon price and assume no corresponding carbon control regime change in the rest of the world.

The resulting list contained 164 sectors which is notably higher than other studies (see Climate Strategies, Droege 2009 for a review) which have tried to assess the competitiveness and leakage impact of the EU ETS on EU manufacturing sectors.

Whilst The Commission's criteria capture some of the key elements which will affect production or investment leakage in a particular sector, the aim of this part of the analysis was to supplement these with the insights from the literature review in order to obtain a further objective perspective on possible criteria.

The processes for criteria development and criteria quantification are similar and overlap

The development of criteria requires describing the nature of carbon leakage and factors describing its effects. The criteria selection described in this first part of the report and the econometric analysis described in the second both implicitly require hypotheses about models of causality and the direction of that causality.

They differ in their starting point which in the first part is predominantly the literature review and in the second quantitative data. The econometric analysis compares statistical correlations between inputs, such as energy costs, and outputs, such as leakage of production or trade flows. An input that does not correlate well can be excluded, and an ongoing process of elimination used to focus in on key inputs, outputs and relationships that fit the data. This compares with a similar but more qualitative process of selection and elimination followed in the first part of this study.

The aim of the qualitative process of the first part is to develop a screening process to select sectors for econometric analysis in the second.

A sector which is deemed at high risk of leakage due to a high score against particular criteria in the screening process should, if the screening criteria were appropriate, also show a high level of leakage in the econometric analysis, if the econometric analysis is robust. This means that the econometric analysis can be used to test the appropriateness of the screening criteria, and vice versa.

The practical aim is to refine the assessment of risk and rank sectors

The practical aim within the overall objectives was to develop criteria which, as a result of using a robust process of development were appropriate for ranking sectors as regards their risk of leakage. The selected sectors were to be appropriate to assessing risks and to allow testing and refinement following the econometric work.

3.2 Approach

The analysis was conducted in five steps:

- Step 1: definition of the framework for leakage analysis (Section 3.3)
- Step 2: identification of explanatory factors for leakage and its effects (Section 3.4 and 3.5)
- Step 3: selection of criteria for leakage (Section 3.6)
- Step 4: development of metrics to support and implement criteria (Section 3.7)
- Step 5: application of metrics (Section 3.8)

This approach recognises the independent parts of the procedure required to proceed to measurable criteria while illustrating the options available at each point in the overall process of selection and elimination.

The final step illustrates the application of the metrics to the NACE 4 sectors.

3.3 The Framework for Leakage Analysis

Alternatives to the IPCC definition of leakage have been proposed

In the context of this study, carbon leakage is a result of reactions by firms and / or consumers to the EU-ETS. However the definition of its scope and hence measurement of its impact can differ. The IPCC finds little evidence of carbon leakage[62] but this is largely as it considers only the impact of climate policy induced changes on the industry itself. In fact, leakage results in ancillary impacts and other commentators suggest defining leakage to include all impacts related to the industry. For example, whilst the main leakage effect is a factory relocating production overseas, ancillary effects can include, for example, the changes in transport, such as road haulage, that reroute to supply the relocated factory.

In this analysis, the aim was to begin with a definition of scope and causality that allowed all possible contributory factors identified in the literature to be included, had a logical structure and captured the decision making processes at firm level.

Model for leakage decision making

The approach chosen in this study to represent firms' decision making in respect of leakage relied on a neo-classical theoretical representation. The key descriptors in this representation are:

- markets
- cost structures
- investment in research and development
- legal and regulatory constraints

The benefit of this approach is that these elements allow the capturing and grouping of a firm's activities relating to carbon leakage and are linked to each other with a simple, but plausible description of incentives: the firm seeks to maximise revenues earned in markets subject to its cost structures and regulatory constraints resulting in a profit-maximising overall strategy.

Although it is a part of the cost structure, investment in R&D is separated out because it has characteristics that make it difficult to combine with other costs, or require assumptions to do so. For example, it may drive technological development across a sector (i.e. for all firms in a sector), even though it is mainly conducted by firms independently. It has the potential to change the sector itself in a way that expenditure on other costs does not. The 'abatement potential' for a sector as described in carbon policy analysis would be considered to result from application of research and development expenditure in the neoclassical model.

Alternative economic approaches could be used to represent the effects of carbon policies, for example those which recognise international political factors. In addition, while using the conventional neo-classical model, other models for the causes of leakage may be applied. For example, a particular type of leakage may occur across a number (or all) of sectors rather than within them. These options were eliminated at this stage on the basis that a simple conception of firms' incentives and behaviour would provide the best framework for considering the other aspects of the use of criteria.

[62] IPCC, Climate Change 2007: Mitigation of Climate Change, Cambridge University Press 2007

Overall, this is an approach which is micro-economic in nature allowing the theory of firm behaviour to be related to the context for its operations, in particular the options available in respect of responses to carbon policies.

Simplification at the framework level

A further simplification is implicit in the sectoral analysis. Firms are assumed sufficiently similar within a sector so that analysis of a sector is sufficiently representative of the firms within it.

Practically, there is a need to choose a level of sectoral definition that appropriately addresses the heterogeneity of firms' activities while allowing comparability between sectors. The terms of reference recognise the possibility of using NACE 3 and NACE 4 levels. In principle, the processes involved in individual products can be identified and leakage may occur at this even more disaggregated level. The chosen objective was to consider impacts at the NACE 4 level in the first instance.

Links between model and terminology used in carbon policy analysis

The links between the theoretical framework and the specific terms used in carbon analysis is shown in the Table 3.1 below. The same categorisation of impacts is used in the deep dives in Chapter 2.

TABLE 3.1: RELATIONSHIP BETWEEN GENERIC MODEL OF THE FIRM AND COMMON CARBON POLICY TERMS

Generic model of firm	Common carbon policy terms
Markets	Pass through ability
Cost Structures	Cost Impact
Investment in Research and Development	Abatement Potential
Legal and Regulatory Constraints	

Source(s) : Entec.

3.4 Explanatory Factors for Leakage and its Effects

The factors important to carbon leakage are identified in this section. The concepts used to explain leakage rather than the model of causation were identified from the literature

No predefined model for causality was proposed before conducting the literature review described in Chapter 2. Instead, the aim was to identify terms used in the literature and group them according to the impact on a firm. The effect was to ignore relationships and causality specifically proposed by authors and to extract only the concepts they used.

The concepts used to explain leakage were identified and grouped under the headings related to carbon policy. These are shown in the following tables. The concepts are listed as used which in some cases results in similarities but also subtle differences. Similar concepts are grouped. Note that as a result of using the nomenclature of carbon policy analysis, a firm's relationship with markets for its *input*s is categorised under costs, whereas the relationship with markets for its *outputs* is categorised under pass-through potential. Factors such as 'substitutability' therefore may occur in both categories.

The synthesis of these comprehensive lists into a more limited number of factors is described in the following section.

Factors resulting in or related to cost pass through

- extra-EU trade intensity
- openness to extra-EU trade
- net imports
- export and import intensities
- changing patterns of world trade
- global trade imbalances - refining
- substitutability of final products
- market and industry structure
- product differentiation
- service differentiation
- market segmentation
- profit margins
- demand growth in the EU
- trade substitution (Armington) elasticities
- preference for domestic production
- energy-capital elasticity of substitution
- inter-fuel (input) elasticity of substitution
- substitutability of factors of production
- import restrictions
- degree of international mobility of capital
- markups in energy intensive industry
- inter-factor substitution elasticity
- cost of instability
- consumption/capacity
- regional differences in the cost of production
- elasticity of relative demand for electricity relative to its price
- import exposure
- fossil-fuel supply elasticity
- position of EU industry in the international market over the last 5 years
- trade volumes in relation to turnover
- exchange rate risks

- differences in the cost shares across regions
- customers reaction to a price increase, based on: vertical integration of industry, quality issues, long term contracting
- international trade and investment linkages
- aggregate demand
- price elasticities
- CO_2 intensity: emissions/turnover ratio
- price-elasticities of imports and exports

Factors resulting in or related to cost impact

- combined direct and indirect production cost increases for a given carbon price as a % of GVA
- higher costs of production (of energy intensive products)
- indirect costs
- direct costs
- energy emissions
- share of carbon costs in overall cost structure (fixed vs. variable, direct vs. indirect)
- energy intensity of production
- percentage potential cost increase
- value at stake
- incremental cost of imposing a carbon constraint in % of product price
- incremental cost of imposing a carbon constraint in % of energy cost
- international transport costs
- capital measures
- vintage structure of capital
- return on investment
- cost pass through rate m- referenced in McKinsey & Company and Ecofys
- demand elasticity- referenced in Reinaud for the International Energy Agency (IEA)
- elasticity of substitution between imported and domestically produced goods
- profit margins as a potential indicator of long-run relocation/investment decisions
- substitutability of inputs
- ease of inter-fuel substitution
- substitution with other less carbon intensive goods
- substitution with other less carbon intensive inputs
- opportunity cost - cement, steel and oil refining
- cash cost equivalent - oil refining
- differences production costs across countries
- exchange rate risks
- impact of ETS
- annualised Environmental Investments (uses annual environmental protection expenditures)
- annual environmental protection expenditures (EPE))
- econometric analysis of survey responses
- inter-fuel substitution elasticity
- implied average product price rise to offset €20/tCO_2e
- ETS cost increase relative to total sector costs
- international capital mobility
- supply elasticity of coal
- impact of ETS: loss in sales (turnover) for three sets of import and export price elasticities

- impact of the EU ETS
- impact of ETS and a unilateral policy that establishes a price on CO_2 emissions in the USA (including impact on industry profitability)
- impact of the EU ETS: indicator that combines intensity of trade and value at stake indicators

Factors resulting in or related to abatement potential

- market penetration rate for new technologies
- diffusion of technological change
- costs of abatement
- relative profitability of technical change
- retirement rate of existing technology
- degree of technical change
- supply elasticities - coal, oil, natural gas
- cross-price elasticities of energy sources
- abatement potential - cement, oil refining, aluminium
- capital intensity

Factors resulting in or related to regulatory and legal constraints

- market structures
- regulatory framework, including subsidies
- legal and political environment
- regulatory framework, including subsidies - cement
- the effect of energy and climate policy outside the EU
- infrastructure quality
- change in number of firms
- change in firm output per firm
- UK employment
- cooperation with domestic/European partners and intra-firm trade
- allowance allocation rules
- economic growth rates of a region
- international capital mobility
- other factors: product differentiation and market segmentation within a sector (including specialty products), close cooperation with domestic/European partners and intra-firm trade, differences across countries in the costs for labour and other input factors, in infrastructure quality, transportation costs, political and legal environment, or exchange rate risks
- leakage-emissions ratio (LE)
- leakage-abatement ratio (LA)

The consortium recognises that the selection of literature reviewed conditions the identification of factors. Chapter 2 describes the approach to selecting the literature which had as a priority the objective of comprehensively covering the body of literature which explicitly addressed carbon leakage. However, as is recognised in the section on the wider literature, firms' reactions to carbon leakage may have parallels with their reactions to other impacts.

For example, decisions made by firms regarding the location of their operations internationally are likely to be conditioned by the nature of international trade for which there is a substantial body of literature. Furthermore location decisions will also depend on their competitors' behaviours and, where there is appreciable trade, this will include international competitors. These aspects of firm behaviour have been well studied in the competition literature.

As well as recognising studies focusing on firms, there is potential information available from studies which focus on other types of policy interventions. Carbon policies such as those applicable to leakage are likely to have parallels with other trade policies which are applied in order to limit (in this case) undesirable trade.

These areas have been identified but not explored due to resource constraints and the extensive carbon leakage literature that was prioritised over investigation of the trade and competition literature. As a result, the approach adopted here will tend to present the views from published experts in carbon policy assessment rather than from experts in firm behaviour or other more general aspects of the firm.

3.5 Synthesis of explanatory factors identified in the literature

The list of explanatory factors from the literature review was too lengthy and contained similar entries to be a basis for development of potential criteria. The descriptions below synthesise these raw factors into a set which represents the range of factors in the literature but avoids repetition.

The synthesis was developed using a working group method including five members from two consortium partners (namely, Entec and Climate Strategies). Each explanatory factor identified from the literature review was considered in turn and the need for a synthesised factor assessed.

For clarity, the synthesised factors were divided into 'basic' and 'composite' types. For example, basic factors are simple measures, such as total emissions. Composite factors contain a degree of contextualisation, such as cost-pass through rate, made up of a combination of measures.

Basic explanatory factors impacting cost structures

The following list outlines the synthesised basic explanatory factors addressing impacts on cost structures:

- total emissions
- employment
- value at stake
- increase in direct costs
- increase in indirect costs
- sunk costs
- international transport costs

Total emissions

Emissions can be measured in absolute terms or in the context of another production variable e.g. emissions per unit of output. By revealing the relative size of each sector and their respective contribution to a region's emissions, this criterion of total emissions can serve as a first proxy for identifying sectors which are likely to be of concern from an overall economic and environmental standpoint.

Employment

Like total emissions, employment effects are often measured as an aggregate for a policy intervention. By revealing the employment in each sector this measure can serve as a first proxy for identifying sectors which will have most impact on an aggregate measure of underlying concern for The Commission.

Value at stake

This factor calculates the cost increase from CO_2 emissions for each sector relative to the sector's contribution to the region's Gross Value Added (GVA). Maximum value at stake refers to the % cost increase from carbon pricing relative to GVA if there are no free allowances. Net value at stake refers to the % cost increase in each sector from higher electricity pricing due to carbon pricing, relative to the sector's contribution to GVA.

Increase in direct costs This measure is a disaggregation of the cost increase from carbon pricing. It refers solely to the sector's direct cost of complying with the rules of the EU ETS, e.g. through purchasing EUAs or through mitigation efforts. It does not include costs resulting from the impact of EU ETS on upstream processes and on electricity generation.

Increase in indirect costs This refers to the increase in costs which downstream firms face from upstream processes and electricity generation as they comply with the EU ETS.

Sunk costs These are costs that once incurred cannot be recovered. A sector with high sunk costs is likely to make very cautious investment choices with a long time horizon and as a result has relatively limited mobility in the short run.

International transport costs International transport cost is an important criterion for determining import leakage because it partially reflects the substitutability of local production with that from regions outside the carbon pricing zone. If international transport costs are low relative to carbon costs, *ceteris paribus*, it may be cheaper for domestic firms to increase imports from areas without carbon pricing than to produce and pay the allowance price.

Composite explanatory factors impacting cost structures

The following list outlines the synthesised composite explanatory factors addressing impacts on cost structures:

- percentage of potential cost increase
- increase in direct and indirect costs
- energy intensity of production

Percentage of potential cost increase This contextualises a cost increase from carbon pricing. By comparing carbon costs with other production costs, it serves as a proxy for how much weight will be given to carbon costs as a factor in investment and production decisions. Other explanatory factors subsumed under this heading include: Share of carbon costs in overall/variable cost structure, incremental cost of imposing a carbon constraint as a % of product price, incremental cost of imposing a carbon constraint as a % of energy cost.

Increase in direct and indirect costs Combined direct and indirect production cost increases for a given carbon price as a % of GVA. This is an extended definition of 'value at stake'.

Energy intensity of production In a similar manner to the factor of total emissions, the energy intensity of production can act as a first indicator of sectors which may be of concern from an environmental and economic standpoint as energy intensive sectors are likely to have high emissions from production.

Local factors impacting cost pass-through

The following list outlines the synthesised basic explanatory factors addressing the cost pass-through ability of the sector (local markets and general factors):

- profit margins
- return on investment (RoI)
- substitutability of final products
- overall demand elasticity
- market segmentation and industry structure
- product differentiation
- service differentiation

Profit margins This factor indicates the flexibility that a sector may have to decide on the level of cost pass through and also the potential impact of additional cost burdens from carbon pricing. A sector operating with very small profit margins may be operating in a market where it is less possible to maintain prices or assume the additional costs. It may be more difficult therefore to pass on the cost increase to consumers or may relocate/shut down. Profit margins were recognised as important from the qualitative analysis, and are shown used in the presentation of alternative weighting systems. However it was not available on a robust and consistent enough basis to be part of the econometric modelling. For example, profit margin data was available for a single year due to there being only a single year of capital and R&D investment data. Operating profit margins (without investment) were available over a longer period but do not represent final bottom line effects.

Return on investment (RoI) Return on investment (RoI) is a key parameter for assessing company performance and its availability and use are widespread. The financial effects of carbon leakage will affect return on investment. As an indicator it may be difficult to use in practice because other financial effects also affect RoI, making it difficult to distinguish the carbon policy impact.

Substitutability of final products Substitutability of products provides an indication of a consumer's responsiveness to a price increase following the introduction of carbon costs to a sector's production schedule. A sector which produces an output which can easily be substituted for an output produced in a different sector may find it difficult to pass through carbon costs to the consumer as they would simply switch their consumption. One example is the substitutability of steel for concrete as a building material.

Overall demand elasticity Demand price elasticity is the demand responsiveness of consumers to a change in product price. A product with high demand elasticity indicates that consumers are highly responsive to a change in price and will increase the level of consumption if the price falls and decrease their level of consumption if the price increases; as would likely be the case for carbon pricing. A price elasticity of demand measurement will aggregate and capture all of the preferences for a particular product expressed by the consumer, including the availability of substitutes.

Market segmentation and industry structure The industrial structure of a sector affects its ability to pass through costs to consumers. Understanding the market segmentation and industry structure can give an indication of a sector's likely responsiveness to carbon costs. It relates to a number of market characteristics including the market size (international and/or domestic), market share between installations, the degree of agglomeration and vertical or horizontal integration. To give a simple example, a monopoly firm in a sector with few substitutes would be able to pass through carbon costs to consumers more easily than in a market which is closer to perfect competition.

Product differentiation When products in a sector are highly differentiated, they are less substitutable. Products may be differentiated based on quality, marketing and branding or content. This is likely to increase a consumer's willingness to pay for a good as they make their consumption decision on factors not exclusively restricted to price because the price of one product in the sector is not directly comparable to that of another. This may increase the ability of firms to pass through the cost of carbon to consumers. Individual consumer preferences may differ as they give different weights to decision criteria (i.e. costs, branding and quality) but can only be modelled in aggregate.

Service differentiation

This factor is an extension of product differentiation. Again if the service provided by a sector is highly differentiated to its competitors, for example the speed of delivery times may be notably less for local markets than for those outside of a carbon pricing zone, it may also affect a consumer's willingness to pay for a product, even when the price increases to reflect an increase in carbon costs.

International trade factors impacting cost pass-through

The following list outlines the synthesised basic explanatory factors addressing the cost pass-through ability of the sector (international trade and the global context):

- demand growth
- import volumes
- export volumes
- elasticity of substitution between imported and domestically produced goods (Armington elasticities)
- extra-EU trade intensity
- changing patterns of world trade

Demand Growth

The location and the rate of demand growth is an important factor in production and investment decisions for installations in a sector. If demand growth is increasing outside regions with carbon pricing, a firm looking to expand capacity may decide to increase production in a non-carbon pricing region. This decision may be compounded by the increased carbon costs that would be faced if they chose to stay in the carbon pricing region. Although this is a very stylised and simplified example, understanding demand growth for a particular sector can give context to the risk of leakage.

Import volumes

Import volumes indicate the level and the location of international imports for a product in a particular sector. This factor builds upon The Commission's use of 'extra-EU trade intensity' by allowing for a more in-depth insight to international competition in a particular sector.

Export volumes

This factor is similar to that of 'import volumes' as it again adds another dimension of understanding to The Commission's 'extra-EU trade intensity' criterion. The sector's main international markets can be identified, as well as their relative size. When this criterion is coupled with other metrics, additional insights can be gained about the sector characteristics which may affect their investment and production decisions. For example, export volumes coupled with domestic consumption levels, coupled with the sector's GVA would broadly indicate the size and importance for the sector in the carbon pricing region.

Elasticity of substitution between imported and domestically produced goods

Armington elasticities reveal the degree of consumer preferences for domestic goods over foreign imports in the sector. There may be a number of reasons for a preference, for example national pride or branding. The impact of a consumer preference for a domestically produced good is that the ability of a firm to pass through the costs of carbon are higher as consumers do not see international products as being directly substitutable with domestic ones.

Extra- EU trade intensity

This is one of the criteria used by The Commission to determine sectors at risk of carbon leakage in the EU. The rationale for including this criterion is that trade exposed industries (i.e. those with a high extra-EU trade intensity) will be at a competitive disadvantage if they face an increase in their carbon costs whilst their competitors abroad do not. This is a key criterion to include when exploring the likelihood of leakage but as this discussion of additional criteria suggests, it needs to be supplemented by other information to gain a more realistic understanding of the nature of the risk of leakage.

Changing patterns of world trade

It is important to consider any underlying patterns of world trade in a particular sector when trying to analyse the impact of carbon pricing on a particular region as this helps disaggregate existing market trends from any additional impact carbon pricing may have on a firm's investment and production decisions.

Composite explanatory factors impacting cost pass-through

The following list outlines the synthesised composite explanatory factors addressing the cost pass-through ability of the sector:

- cost pass through rate
- export and import intensities
- global trade imbalances

Cost pass through rate

This is a metric developed in a study by McKinsey and Ecofys which quantifies the degree of costs that are passed on to consumers when a sector faces carbon costs.

Export and import intensities

The metric builds upon the import and export volumes by comparing for a particular sector.

Global trade imbalances

This factor is intended to offer insights into global concentrations of particular sectors.

Basic explanatory factors addressing abatement potential

The following list outlines the synthesised basic explanatory factors addressing abatement potential in the sector:

- substitutability of inputs
- substitutability of fuels
- substitutability of capital investment for energy consumption

Substitutability of inputs

If a sector can substitute an existing input to production with a less carbon intensive input, then their costs from carbon pricing will fall. This may not be possible for all sectors in the short term but new production technologies or techniques may be introduced which allows for substitutability of inputs in the mid-to long term.

Substitutability of fuels

If a sector can substitute their existing fuels for those with lower carbon intensity (e.g. moving away from coal fuel to renewable) this will also reduce their carbon costs.

Substitutability of capital investment for energy consumption

If a sector can reduce the energy intensity of their production processes through use of other factors of production then this will also reduce their carbon costs.

Composite explanatory factors addressing abatement potential

The following list outlines the synthesised composite explanatory factors addressing abatement potential in the sector:

- market penetration rate for new technologies
- relative profitability of technical change

Market penetration rate for new technologies

This metric indicates the adaptability of a sector to new lower-carbon technologies and production processes. It will depend on a number of factors including the existing capital infrastructure of the sector, the maturity of the new technology and the nature of the new technology (incremental or step-change).

Relative profitability of technical change

The relative profitability of technical change is the increased revenue net from the technology, net of the increased costs of introducing it. If the relative profitability of technical change is higher than the increase in profits from relocation or increased production in non-carbon pricing regions, the risk of leakage may be reduced.

Basic explanatory factors addressing regulatory and legal constraints

The following list outlines the synthesised basic explanatory factors addressing regulatory and legal constraints in the sector:

- subsidies
- import restrictions
- legal and political environment
- infrastructure quality
- the effect of energy and climate policy in the rest of the world

Subsidies

Regional subsidies distort the market as they partially shield installations from the full cost of production. The location of sector specific subsidies will also be a factor for installations to consider when making investment and production decisions. Subsidies may also be for upstream facilities e.g. electricity generation

Import restrictions

Import restrictions can take the form of both quantity and price restrictions. An example of a quantity restriction would be the banning of a particular product or a fixed quota and for price restrictions, an import tariff. These restrictions would have to pass WTO scrutiny and for this reason are unlikely to be relevant for all sectors.

Legal and political environment

When installations make investment and production decisions, they also consider the legal and political environment of a region. Political instability, other geo-political factors and unfavourable legal conditions can impede the operation of an installation and sector.

Infrastructure quality

Another factor affecting a firm's production and investment decisions is the quality of infrastructure in the non-carbon pricing region. A simple example of how this factor impacts on a firm's production and investment decision would be transport infrastructure. If this is of poorer quality in the non-carbon pricing region, the installation may have to increase expenditure on improving local transport infrastructure. This may be more significant than carbon costs.

The effect of energy and climate policy in the rest of the world

Installations will incur costs with complying with other forms of environmental and climate policy which need to be compared to carbon costs.

Synthesised factors and literature sources

Tables 3.4a to 3.4d below identify the factors used by each of the literature sources. The left hand column shows the synthesised factor. The next column "n Refs" shows the number of sources that suggest use of this factor. The third column is a unique code for each report. The columns to the right are the details of the source. The 'value at stake' is therefore quoted by 4 sources as a cause or potential cause of carbon leakage. The first source is the Carbon Trust's 2008 report "EU ETS impacts on profitability and trade: a sector by sector analysis".

3.6 Selection of Criteria

The method of selecting criteria is discussed here, beginning with the overall approach, then discussing The Commission's and US criteria, and then including the additional criteria derived from the list of explanatory factors.

Approach to selection

Responding to the Terms of Reference for the study, the criteria selected should provide a method of selecting ten sectors for further econometric analysis.

More generally the selection of criteria should:

- respond to the objectives implicit in the definition and use of carbon leakage as a concept
- preferably allow sectors to be ranked

In addition, criteria should

- be capable of use singly and in combination
- be robust to issues of timescales

Due to practical constraints the following are also important aspects:

- that data are available on a standardised basis for sectors to be considered
- that criteria can be tested

As a sector may be selected to be at risk as a result of meeting more than one criterion, small differences in definitions may be less important than the method of combining criteria. The difference in definition may affect understanding and assessment of impacts.

The Commission's criteria are implicitly required as part of the set of criteria which capture decision making at the firm level. They are discussed together with the US criteria which are similar in nature.

Overarching framework for criteria

The impacts of leakage are understood as being negative in the context of the aspects of EU markets and society as represented in:

- pre-existing legislation, including the Treaty of Rome
- ongoing Commission policy development on employment, production & competitiveness
- The Commission's environmental objectives

Criteria selected may acknowledge wider impacts as well as on firms

More specifically, leakage may affect:

- changes in competitiveness (profits and market shares) of European industry vis-à-vis Rest of the World
- trade (assumed to be beneficial unless proved otherwise)
- employment
- aggregate carbon emissions

These guiding principles can be seen as an overarching reference for the selection of criteria and their use in identifying sectors at risk.

The Commission's and US Criteria

The Commission's criteria have been specified earlier, and are restated in Box 3.1.

BOX 3.1: THE COMMISSION'S CRITERIA TO IDENTIFY SECTORS AT RISK OF CARBON LEAKAGE

A sector meeting any one of the following thresholds in the European Commission's assessment is deemed to be at risk of leakage:

- increase in production costs > 5% of GVA, and extra-EU trade intensity > 10%;
- increase in production costs > 30% of GVA
- extra-EU trade intensity > 30%

These factors are calculated at €30/t carbon price and assume no corresponding carbon control regime change in the Rest of World.

Source(s) : Entec and European Commission.

The US criteria from the American Clean Energy and Security Act, and known after the authors as Waxman-Markey, are stated in Box 3.2.

BOX 3.2: THE US WAXMAN-MARKEY CRITERIA TO IDENTIFY SECTORS AT RISK OF CARBON LEAKAGE

Sectors with any of:

- Energy or greenhouse gas intensity > 5% and trade intensity > 15%
- Energy or greenhouse gas intensity of at least 20%

Measures developed under Waxman-Markey use a carbon price of $20/t.

Source(s) : Entec.

The US has different and in some cases better data than the EU collected on a different basis. The US criteria cannot be used easily for The Commission without substantial use of proxy data which may be available but of which not all is public. It is believed that greenhouse gas intensity data could thereby be derived for comparative purposes.

In terms of the model of the firm, The Commission's criteria cover both its upstream and downstream (in markets and in cost structures). As such they capture the impact of policies on its inputs and on the prices of its outputs.

Under the overarching criteria, The Commission's leakage criteria can be seen to

TABLE 3.3: RELATIONSHIP BETWEEN GENERIC MODEL OF FIRM AND EUROPEAN COMMISSION AND US CRITERIA

Generic model of firm	Commission Criteria	US Criteria
Markets	extra-EU Trade intensity	Trade intensity
Cost Structures	Production costs	Energy costs
Investment in Research and Development		
Legal and Regulatory Constraints		

Source(s) : Entec.

capture concern with the Commission's trade and costs of production. There are implicit rather than explicit effects on employment and the other overarching criteria.

In use, The Commission's criteria have a number of concerns. They include:

- large number of sectors identified;
- the inherent heterogeneity of sectors;
- additional ("qualitative") criteria, while identified, were not used;
- lack of a clear basis for selection of threshold values;
- mismatches between sectors/products;
- need for special data from Member States to calculate direct and indirect costs;
- use of a GHG intensity measure based on data which are not publicly available.

Criteria based on synthesised explanatory factors

The synthesised factors are shown in the following table. A process of review and discussion including all three consortium partners and DECC was undertaken in order to select criteria which could be used to score sectors. The main objectives columns indicate how the criteria may be used. The EC_IA columns indicate that the criteria were considered in The Commission's impact assessment of the determination of sectors at risk of carbon leakage. The three columns: reduce emissions, prevent relocate and maintain margins indicate the broad area of information provided by the criteria.

The selected criteria are shown as highlighted rows. A priority level regarding their use is shown in the 'Overall Priority' column. The reasons for elimination of specific potential criteria are shown in the Notes column.

TABLE 3.4A: SYNTHESIS OF EXPLANATORY FACTORS FROM LITERATURE REVIEW, (WITH SELECTED CRITERIA HIGHLIGHTED)
IMPACT ON COSTS

	# Refs	Notes	Possible Data sources or Proxy	{		Main objectives			}
Impact on Costs				used in EC IA basis 164	In EC IA, not used	reduce emissions	prevent relocate	maintain margins	Overall Priority
Basic Criteria									
Total emissions	1	used in EC criteria	CITL, EC_IA underlying data	x		x		x	
Employment			Eurostat SBS Enterprise size						
Value at stake	**5**	**= EU production value indicator**	**[composite of basic indicators]**	**x**	**x**				**1**
Increase in direct costs	2	used in EC criteria	in EC_IA underlying data (using MS submissions)	x	x			x	
Increase in indirect costs	2	used in EC criteria	in EC_IA underlying data (using MS submissions)	x	x			x	
Sunk costs	**1**	**Potential additional criteria**	**Eurostat SBS capital investment as a proportion of production value**				**x**	**x**	**4**
International transport costs	**5**	**Potential additional criteria**	**GVA/tonne**		**x**		**x**		**3**
Composite Criteria									
Percentage potential cost increase	1	~EC production cost criteria	[composite of basic indicators]	x			x	x	
Combined direct and indirect production cost increases for a given carbon price as a % of GVA	5	~EC production cost criteria	[composite of basic indicators]	x			x	x	
Energy intensity of production	1	~EC production cost criteria	[composite of basic indicators]	x			x	x	

Note(s) : Emboldened criteria were selected for application.
In this Table 'EC' refers to the European Commission.
Source(s) : Entec.

TABLE 3.4B: SYNTHESIS OF EXPLANATORY FACTORS FROM LITERATURE REVIEW, (WITH SELECTED CRITERIA HIGHLIGHTED)
ABILITY TO PASS COSTS THROUGH

	# Refs	Notes	Possible Data sources	{ Main objectives }					
Basic Criteria (local markets and general)			(or proxy)	used in EC IA basis 164	In EC IA, not used	reduce emissions	prevent relocate	maintain margins	Overall Priority
Profit margins	**3**	**Potential additional criteria**	**SBS Eurostat NACE-4 Operating surplus**		**x**			**x**	**2**
Return on investment	1	difficult to separate out carbon impacts	SBS Eurostat NACE-4 GVA and Operating surplus					x	
Substitutability of final products	6	difficult data	SBS Eurostat NACE-4 Operating surplus						
Demand elasticity	1	difficult data	sector studies				x		
Market Segmentation and Industry structure	**10**	**Potential additional criteria**	**NACE4 heteregeoity within each NACE3; use US HHI?**		**x**			**x**	**2**
Product differentiation	3	difficult data						x	
Service differentiation	2	difficult data						x	
Demand growth	**4**	**Potential additional criteria**	**Sector turnover, deflated**				**x**		**2**
Basic Criteria (international trade and global context)									
Import volumes	3	used in EC criteria	Eurostat Prodcom						
Export Volumes	1	used in EC criteria	Eurostat Prodcom						
Elasticity of substitution (Armington trade elasticities)	5	difficult data	indicative from academic studies		x		x		
Extra-EU trade intensity	**6**	**EU trade intensity indicator**	**[composite of basic indicators]**						**1**
Changing patterns of world trade	6	needs definition of characteristics	UN stats: proportion of EC as % world trade in commodity				x		
Composite criteria/metrics									
Cost pass through rate (as per McKinsey and Ecofys)	2	high level for sectors	as a composite, difficult to apply at NACE-4 level					x	
Export and import intensities(separately)	1	Potential additional criteria	[composite of basic indicators]		x				
Global trade imbalances	1	needs definition of characteristics	GAINS/McKinsey information, but at high NACE level		x	x			

Note(s) : Emboldened criteria were selected for application.
In this Table ‘EC’ refers to the European Commission.
Source(s) : Entec.

TABLE 3.4C: SYNTHESIS OF EXPLANATORY FACTORS FROM LITERATURE REVIEW, (WITH SELECTED CRITERIA HIGHLIGHTED)
ABATEMENT POTENTIAL

	# Refs	Notes	Possible Data sources	{		Main objectives			}
Abatement Potential: Basic Criteria			(or proxy)	used in EC IA basis 164	In EC IA, not used	reduce emissions	prevent relocate	maintain margins	Overall Priority
Substitutability of inputs	7	data inconsistent between sectors	sector studies			x	x		
Substitutability of fuels	7	data inconsistent between sectors	sector studies		x	x	x		
Substitutability of capital investment for energy consumption	1	data inconsistent between sectors	sector studies		x	x	x		
Abatement Potential: Composite Criteria									
Market penetration rate for new technologies	4	data inconsistent between sectors	inverse of sunk cost measure			x			

Note(s) : Emboldened criteria were selected for application.
In this Table 'EC' refers to the European Commission.
Source(s) : Entec.

TABLE 3.4D: SYNTHESIS OF EXPLANATORY FACTORS FROM LITERATURE REVIEW, (WITH SELECTED CRITERIA HIGHLIGHTED)
REGULATORY, LEGAL AND OTHER FACTORS

	# Refs	Notes	Possible Data sources	{		Main objectives			}
Regulatory, Legal and Other Factors:				used in EC	In EC IA,	reduce	prevent	maintain	Overall
Basic Criteria			(or proxy)	IA basis 164	not used	emissions	relocate	margins	Priority
Subsidies	2	assumed structural	National data				x	x	
Import restrictions	1	assumed structural	National data				x	x	
Legal and political environment	1	assumed structural					x		
The effect of energy and climate policy in RoW	3	needs definition of characteristics	Published national commitments				x		
Infrastructure quality	4	needs definition of characteristics					x		

Note(s): Emboldened criteria were selected for application.
In this Table 'EC' refers to the European Commission.
Source(s): Entec.

The note 'used in EC criteria' indicates that these particular criteria would impact the value of one of The Commission's criteria which could therefore be used instead in the first instance. Such criteria were therefore eliminated.

More generally, the criteria shown in the table in square brackets were rejected outright on grounds of data complexity. For example, product and service differentiation and changing patterns of world trade had problems associated with definition as well as of data availability and data comparability.

Other criteria recognised as having difficult data issues were those which involved assessing market responses. This study required the comparison of sectors which would have required market definition and other information collected on comparable basis for different sectors. Although this aspect of the market is covered in the second econometric part of the study for 10 sectors, obtaining comparable information from many sectors would not be possible in the timescale and hence these criteria were eliminated at this stage. Within a smaller group of sectors such criteria might have been retained as factors characterising the market were recognised by the sources listed above as of importance.

The criteria noted as 'assumed structural' are factors which though they might matter to leakage will be common to all firms within that regulatory or market structure for example, subsidies and import restrictions. These are better analysed on their own terms rather than as intrinsic characteristics to a sector.

The cost pass through rate is a key measure, but depends on a number of underlying sector and market specific factors. These include demand elasticities and market segmentation type issues which were already identified as not suitable for wide ranging sector comparisons. Cost pass through rate is defined by McKinsey at a high level and cannot be used to distinguish sectors at NACE 4 level.

The following potential criteria were retained

Based on this assessment the following potential criteria were then retained. Issues of data availability were discussed at the time and proposals for use of data are described for each of these potential criteria:

- *value at stake*: the direct and indirect costs as used for The Commission's criteria
- *extra-EU trade intensity*: The Commission's trade intensity criteria
- *sunk costs*: for which a data proxy was suggested as Gross investment in tangible goods for 2004 (the year for which it was collected by Eurostat) divided by Value added at factor cost
- *international transport costs*: a proxy based on data of Prodcom Value of sales divided by Prodcom Sold_Volume
- *profit margins*: implicitly Operating surplus minus Investment, then divided by Production Value
- *market segmentation and industry structure*: number of Employees in companies with greater than 250 employees as a proportion of total employees in the sector
- *demand* growth: the average annual growth in Prodcom Sold_Volume over the period 2004 to 2008

3.7 Development of Metrics

The seven criteria assessed through the qualitative process above were then considered for the development of quantitative measures that could be used to rank sectors.

Refinements to criteria

Market segmentation and industry structure had the most references (10) of any factor quoted in the literature as affecting the risk of leakage. However, although most quoted there was little consistent definition of measurable indicators and, despite its acknowledged importance, it was eliminated on the grounds that comparability could not be ensured between sectors.

Sunk costs were recognised also as important but the proxy was considered to be too general as to be indicative of sunk costs alone. Furthermore as sectors had inherently different needs and characteristics for recurring investment, even a specific value of investment did not necessarily indicate sunk costs. Investments might be overseas or in mobile equipment. In summary, identifying specific sunk costs was thought to be overly ambitious.

Criteria selected for development of quantitative measures

As a result of refinements, the final list of criteria was as selected below, together with the definition of the data to be used:

- *value at stake*: the direct and indirect costs as used for The Commission's criteria. The data is from The Commission's impact assessment
- *extra-EU trade intensity*: The Commission's trade intensity criteria, similarly from The Commission's impact assessment.
- *profit margins*: SBS Eurostat NACE-4 Operating surplus minus Investment all divided by Production Value for 2004, the year for which gross investment figures are available.
- *demand growth*: the average annual growth in Prodcom Sold_Volume over the period 2004 to 2008. Growth is based on available data, in a number of instances (roughly estimated at 5%), data for the full 5 year period is incomplete. Results are based on years for which there is reported data.
- *international transport costs*: Prodcom Value of sales divided by Prodcom Sold_Volume (for products with units of kg). for the average values over the period 2004 to 2008.

Issues in the use of multiple criteria

Some criteria will affect some sectors more than others. Using more criteria at once requires a choice of their relative importance. The possibilities include independent use (for example using either The Commission's or US criteria); sequential use (using one criteria and then the next); and weighting systems which balance criteria.

In all cases a judgement needs to be taken over which criteria or group of criteria should be emphasised. In order to select an appropriate balance of criteria, any proposed system should be tested as only one final system can be used.

3.8 Application of Metrics

The application of metrics is shown below in one main table and a set of scenarios.

The development of the metrics was based on Eurostat data, in particular the Structural Business Statistics (SBS) and the Prodcom database. A number of checks were done for outliers based on extreme values. Specific elements of the Prodcom database therefore needed to be excluded. For some sectors the SBS statistics were also not available.

Metrics for each sector

Table K.1 in Appendix K shows the calculated measures for the five criteria selected above. The five columns on the right show the same metrics but normalised for a range of 0 to 100, so that the weighting system can be more easily applied. The normalisation system needs to allow for negative figures (for example for negative growth). The method used is to take the difference between the largest and smallest figures and then locate each value on this range. The lowest normalised value will therefore be 0, and the greatest 100.

A number of data issues had to be overcome in constructing these tables. V alues of 0 are used where data was inadequate or poor, so that the ranking could be carried out. However the input data is repeated in the scenario output so that such concerns can be identified when reviewing the data.

Weighting scenarios using metrics

The use of multiple criteria requires a choice of the weighting of each. In this study this has been addressed by the development of different weighting scenarios.

The weightings used the normalised values of the metrics. The first five scenarios weight only one criterion and this shows the effect of the criteria, were they to be considered alone. The other weighting scenarios are described in the title. Note that the Weighted_1_transp_Is_20 scenario uses 18 as the weighting for transport (rather than the 20 implied by the title) as a result of rounding.

Negative weights are used for Profits and Average growth as lower values will increase the risk of leakage.

As mentioned above, the results are only distorted if care was not taken to review the input data before making decisions based on it. Where input data shows a zero value, this should be checked against the main table to confirm whether data exists.

TABLE 3.5: WEIGHTING SCENARIOS FOR APPLICATION OF MULTIPLE CRITERIA

Scenario		EC IA Costs/GVA	EC IA Trade/GVA	Profits 2004	Av. growth 2004-08	sales/kg 2004
1	Just % cost	100	0	0	0	0
2	Just % Trade	0	100	0	0	0
3	Just % Profit	0	0	-100	0	0
4	Just % Growth	0	0	0	-100	0
5	Just Transport	0	0	0	0	100
6	Weighted_1	37	37	-11	-11	5
7	Weighted_1 no transport	39	39	-11	-11	0
8	Equal cost and trade only	50	50	0	0	0
9	EqualCost&Profit only	50	0	-50	0	0
10	EqualCost&Growth only	50	0	0	-50	0
11	EqualTrade&Profit only	0	50	-50	0	0
12	EqualTrade&Growth only	0	50	0	-50	0
13	Weighted_1_transp_Is_1	38	38	-11	-11	1
14	Weighted_1_transp_Is_3	38	38	-11	-11	3
15	Weighted_1_transp_Is_7	36	36	-10	-10	7
16	Weighted_1_transp_Is_10	35	35	-10	-10	10
17	Weighted_1_transp_Is_20	32	32	-9	-9	18
18	Weighted_1_Bias 10 to Cost fromTrade	47	26	-11	-11	5
19	Weighted_1_Bias 20 to Cost fromTrade	58	16	-11	-11	5
20	Weighted_1_Bias minus 10 to Cost	26	47	-11	-11	5
21	Weighted_1_Bias minus 20 to Cost	16	58	-11	-11	5

Note(s) : ECIA refers to European Commission Impact Assessment.
Source(s) : Entec.

3.9 Selection of Sectors

The process of applying the criteria resulted in a ranking of sectors which varied relatively widely, depending on which criteria were used and the weightings that were applied.

This was in part the result of the comprehensive nature of the work which sought to reflect the many factors quoted in the literature as affecting leakage rather than start with a predefined model. However, the variation also resulted from the fact that, for the quantitative analysis, the factors were represented by proxies constrained by available data.

The weighting scenarios shown in Table 3.5 each produced different rankings.

The Commission's system can also be understood in terms of weighting scenarios, with essentially three weighting systems in parallel: one with 100% weighting on trade intensity; the second with 100% on production costs and the third with weighting on both trade intensity and production costs. Sectors at risk are those which are sufficiently highly ranked under any of these systems.

As indicated earlier, in order to investigate The Commission's thresholds, the sector selection was also intended to include sectors identified as having a risk of leakage above and below The Commission's thresholds and hence would best inform the comparative testing in the econometric analysis.

After a review of the alternative weighting systems, DECC selected the sectors in Table 3.6 below and provided reasons as identified in the righter most column.

TABLE 3.6: DECC SELECTION OF SECTORS

NACE	Sector	GVA	Trade Intensity	Reason for inclusion
2413	Manufacture of other inorganic basic chemicals	11.9	31.7	Very high trade and moderate cost
2611	Manufacture of Flat Glass	8.0	21.0	>5%cost, >10% trade and not already studied
2416	Manufacture of plastics in primary forms	3.0	27.1	Near 30% trade cut-off
2614	Manufacture of glass fibres	3.6	23.4	Low cost, moderate trade
2640	Manufacture of bricks, tiles and construction products, inc baked clay	9.8	2.7	Above 5% cost, but below 10% trade
2652	Manufacture of Lime	65.2	2.6	Previously identified at risk
2662	Manufacture of plaster products for construction purposes	3.2	5.7	Low cost and low trade
2752	Casting of steel	2.0	-	Qualitative assessment
2931	Manufacture of agricultural tractors	>5 <30%	31.1	>5%cost, >10% trade and not already studied
3410	Manufacture of motor vehicles	0.5	28.9	High trade intensity - but low cost. Example of complex manufacturing

Source(s) : DECC.

4 Estimating Price Elasticities

This chapter presents a summary of the data, methodology, diagnostic results and summary results of the estimation method employed to derive elasticities for the 14 sectors. Four sectors were estimated as part of a project for DG Enterprise[63] and the results have been employed in this study.

More details for each of the ten sectors (listed in Table 3.7) investigated for DECC can be found in Appendices A to J.

4.1 Data Requirements and Source

The econometric method employed is a panel data technique that makes use of data disaggregated by the 27 EU Member States over the period 1995-2007. Table 4.1 lists the data available for use in the estimation of the final equations. Wherever possible and appropriate, data at the NACE four-digit level were used; otherwise NACE three and two-digit data were used in their place. The equation specifications are detailed in Section 4.2.

For some explanatory variables in the equations, a variety of alternative proxies have been considered eg in the case of activity, both GDP and the output of main demanders are available for inclusion in the final estimated equations. NACE four-digit data are from Eurostat (Industry, Trade and Services database), as are the trade data (ComExt database). Macro variables, such as income and world GDP, are from

TABLE 4.1: SUMMARY OF VARIABLES REQUIRED IN THE ESTIMATION

Variable	Proxy variables tested/used	Source
Demand equation		
Industry Output	Value Added at Factor Cost	Industry, trade and services database, Eurostat
	Production Value	
Domestic Output price	Domestic Price Indices	Industry, trade and services database, Eurostat
Income (macro level)	GDP	
	Weighted output of principal consumers	
Supply Instruments		
Cost factors	Producer Price Indices	Industry, trade and services database, Eurostat
	Wages and Salaries	
	Personnel Costs	
	Total Industry Employment	
Import equation		
Imports	Import Value	ComExt database, Eurostat
Import price	Import Price Index	Industry, trade and services database, Eurostat
Export equation		
Exports	Export Value	ComExt database, Eurostat
Export price	Export price index	Industry, trade and services database, Eurostat
World demand	World GDP weighted by trade with EU27	E3MG database, Cambridge Econometrics.

Source(s) : Cambridge Econometrics.

[63] http://ec.europa.eu/enterprise/policies/sustainable-business/climate-change/energy-intensive-industries/carbon-leakage/files/cl_executive_summary_en.pdf

Cambridge Econometrics' (CE) E3ME and E3MG databases which have been constructed using a range of sources[64].

Data processing

In practice, raw datasets are often incomplete and must undergo some form of filling to ensure a dataset that is sufficiently complete for the purposes of estimation.

The following stages are taken to fill missing data points:

- Stage I: use growth rates of variables from CE's E3ME database and apply to the NACE two-digit level data from Eurostat, in order to fill the missing gaps in the sample
- Stage II: use the filled NACE two-digit growth rates to fill missing gaps in the NACE three-digit data
- Stage III: use the filled NACE three-digit growth rates to fill missing gaps in the NACE four-digit data

Where all the data in a particular series are missing, the above procedure cannot be applied. Instead, the country to which the data relate is either excluded from the estimation sample or some proxy is used, such as a series from another country.

The data availability for each sector, and the steps taken to overcome cases of missing data, are detailed in the appendices.

4.2 Econometric Method

An early review of data availability at NACE four-digit level revealed that the time coverage of most of the required variables was limited, making the sample size impractical for time-series work. For this reason, the chosen econometric method is a short time-series panel method which allows for the pooling of data from different Member States to deal with the small sample size.

A panel model increases the number of observations substantially compared with estimating separate time series equations for each Member State. In contrast to a cross-section approach, it allows us to use all the data within the specified time period.

Another benefit of fixed effects is that it allows us to deal adequately with all the relevant cross-sectional heterogeneity.

The benefits of a short time-series model are the availability of period fixed effects and the reduced relevance of time series. Furthermore, the use of a short time-series mitigates the possibility of elasticities changing over the span of the sample.

The econometric methodology was implemented using scripts in the EViews econometrics software.

Equation specifications

An output-price increase, other things being equal, can be expected to lower total demand for an industry's product through:

- lower domestic demand, where products are highly substitutable by cheaper alternative products or where products are not necessities and therefore consumers stop buying them altogether
- higher import demand (import substitution), where cheaper imports are substituted for the domestic demand

[64] Data sources for E3ME and E3MG database include Eurostat, OECD STAN, AMECO, ILO, and National Statistics. For more information see www.e3me.com and www.e3mgmodel.com

- lower export demand, where exports are less competitive globally and therefore substituted by cheaper alternatives produced elsewhere

Consequently, six types of elasticities are considered; the domestic demand own price elasticity and cross price elasticity (import prices); the export own price elasticity and cross price elasticity (import prices – as a proxy) and the import own price elasticity and cross price elasticity (domestic prices).

The general specification for the three equations is presented below. It should be noted that all parameters other than the constant and fixed effects are expressed in logs. This allows the parameters to be interpreted as elasticities.

Domestic demand specification

$$D_{it} = Q_{it} - X_{it} = \alpha + \beta_1 GDP_{it} + \beta_2 P_{it} + \beta_3 PS_{it} + \beta_4 PM_{it} + \beta_5 GDP\_DEFLATOR_{it} + \eta_i + \delta_t + \varepsilon_{it} \quad (1)$$

with the following instruments considered:

- WS_{it} = wages and salaries in the industry
- PPI_{it} = producer price index for the industry
- E_{it} = number of persons employed in the industry

and where:

- *i* subscripts represent the cross-sectional dimension (Member States)
- *t* subscripts represent the time dimension (years)
- D_{it} = domestic demand for domestic production of the industry
- Q_{it} -X_{it} = quantity supplied by the industry to the domestic market (Domestic Production value)
- GDP_{it} = Gross Domestic Product (macro variable) of Member State *i*
- P_{it} = domestic output price of the industry
- GDP_DEFLATOR = GDP deflator
- PME = price of extra-EU imports of the industry
- η_i is the Member State-specific fixed effect
- δ_t is the period-specific fixed effect
- ε_{it} is the idiosyncratic shock

Equation (1) sets out the specification for domestic demand for the products of an industry. The dependent variable in the domestic demand equation is the production value of the industry deflated to obtain a real (constant price) value. It is important to realise that this dependent variable is the domestic demand for the product of the domestic industry (it does not include exports). As such the price elasticities obtained will be the price elasticity of demand for the domestic product (ie only demand from domestic consumers and not overseas consumers) and not the price elasticity of demand by domestic consumers for all production available (which would also include the demand for imports).

The use of domestic production (excluding exports) as a measure of demand is justified by the fact that in neoclassical microeconomic models (of the sort estimated here) demand and supply are assumed to be in equilibrium. This approach is the standard method of estimating such equations. However, as discussed in the next section, because price and quantity are also potentially affected by the supply relationship, the model uses instruments to separate out this impact. Where there is no evidence of endogeneity, these instruments are omitted.

Demand is explained by an income measure, the price of the product and the price of imports of the same product. In addition, the GDP deflator is included as a general measure of inflation to allow for the use of WS and PPI as instruments.

No restrictions are imposed on the coefficients of the equation; however, economic theory and past experience provide some indication of the nature of possible relationships between the variables and hence the expected sign for the estimated coefficients (elasticities). Classical microeconomic theory suggests that an increase in price will lower product demand. Hence, a negative relationship between price and demand is expected. Positive relationships are expected between demand and income. This is because as the level of income increases (all other things being equal) demand for a product should also increase. Import prices are included in the equation since imports might be near-perfect substitutes for the product of an industry. We expect rising import prices to have a positive impact on domestic demand. Generally, the extra-EU import price (PME) is used in the estimation. We have tried using the price of intra-EU imports (PMI) as well, but the coefficient is usually insignificant.

Two alternative measures of income are used: national income (GDP) and total output from the industry sectors that are the major customers for the output from the industry (Qint). GDP is the preferred measure as it captures the income of the entire economy However in cases where its explanatory power is weak; Qint is used as an alternative. If the explanatory power of GDP is weak, this suggests that demand for the industry's products is less connected to overall economic performance and more to economic performance in certain industries which does not necessarily vary in line with the economy as a whole.

The instruments used in the specification all represent factors that relate to the cost or the productive capacity of the industry. As such these factors are expected to be in the national supply equation but not in the demand equation. In order to use these as instruments, we must ensure that they satisfy the exclusion restriction discussed in the next section on simultaneity.

Wages and salaries (WS) for an industry could in principle impact on industrial demand as they also constitute a form of income. However, as discussed above the inclusion of a more general measure of income (GDP or Qint) in the equation is likely to mitigate this impact given the relative size of the industry.

The Producer Price Index (PPI) of an industry could also in principle affect the industrial demand through its effect on the general price level. Again, as discussed above, by including the GDP deflator in the equation we are likely to eliminate this effect. Where PPI data is poor, we omit it as an instrument. In this case, GDP deflator can also be excluded as an explanatory variable.

The number of employees in an industry is a measure of industrial capacity. This justifies its inclusion as an instrument.

Import demand specification

$$M_{it} = \alpha + \beta_1 GDP_{it} + \beta_2 PME_{it} + \beta_3 P_{it} + \beta_4 PMI_{it} + \eta_i + \delta_t + \varepsilon_{it} \quad (2)$$

with the instruments:

- WWS_{it} = weighted industrial wages and salaries in non-EU countries
- EWS_{it} = weighted employment in non-EU countries

and where:

- M_{it} = imports from Extra-EU countries into country i of the goods of the industry
- PMI_{it} = price of imports from other Member States in the EU
- PME_{it} = price of imports from other Member States in the EU

The logic behind the specification is similar to that justifying the demand equation. In this case, we would expect a rise in import prices to have a negative impact on import demand whereas a rise in domestic prices will have a positive impact on import demand.

The key decision to make here is the choice of instrument. It is necessary to find a variable which belongs in the world export supply equation for the industry. It was decided to use wages and salaries and employment in non-EU countries weighted by their share of trade with the Member States in that industry as a proxy for world costs of supply.

Imports from EU Member States provide competition for imports from outside the EU and therefore the former is effectively behaving as a close substitute to the latter. Therefore PMI is included to control for the substitution effect. We would expect imports from outside the EU to increase as the import price from inside the EU increases. However, the limitation in the quality of PMI data means that the sign for it might be negative or insignificant.

Export demand specification

$$X_{it} = \alpha + \beta_1 WD_{it} + \beta_2 PXE_{it} + \beta_3 PME_{it} + \eta_i + \delta_t + \varepsilon_{it} \quad (3)$$

with the following possible instruments:

- WS_{it} = wages and salaries in the industry
- PPI_{it} = producer price index for the industry
- E_{it} = number of persons employed in the industry

and where:

- X_{it} = exports of Member State i for the industry to non-EU countries
- PXE_{it} = price of exports for the industry to non-EU countries
- PME_{it} = price of imports for the industry to non-EU countries
- WD_{it} = Trade-weighted world income

Equation (3) represents the export demand equation to be estimated. It is similar in form to the domestic demand equation. Import prices are used as proxies for the domestic price in foreign countries. The justification for including this in the equation is that domestic production in those countries represents a near-perfect substitute for the EU exports. The instruments chosen in this case are identical to those for domestic demand since for these sorts of highly-traded goods similar factors will influence supply to domestic and export markets.

In contrast to the domestic and import demand equations, while we have included a measure of income (world GDP) in the export equations here, it is typically omitted. This is because such a variable would not vary sufficiently between cross-sections. However, the exclusion of the variable should not bias the results since it would vary over time and, thus, would be captured by the period fixed effects.

4.3 General Issues in the Estimation

Simultaneity bias

Simultaneity bias arises when an explanatory variable is determined simultaneously with the dependent variable. It is a form of endogeneity; that is, it makes it impossible to decompose variation in the dependent variable into observed and unobserved components. For example, in a demand equation, price determines demand. However, prices and quantities are also potentially determined by a supply relationship. The effect is that estimates are biased.

A standard approach is to use the method of instrumental variables (IV) which requires the identification of variables (instruments) that satisfy the following conditions:

- *order* – there must be at least one instrument per endogenous regressor
- *rank* – the instrument must be correlated with the endogenous regressor
- *orthogonality* – the instruments must not explain residual variation in the dependent variable (ie they must not belong in the model as regressors given the other regressors that have already been included in the model)

In this case, ideal candidates for the instruments are the cost factors (such as industry wages or capital costs etc) or the capacity factors which determine supply but may not determine demand (they do not belong in the demand model). In order to use these variables, we must ensure that the above conditions are satisfied.

A measure of personnel costs (such as industry wages) could in principle impact on industrial demand as costs constitute a form of income. However, the industries being studied make up such a small proportion of the economy that the impact of personnel costs in one industry on general demand is irrelevant provided that a more general measure of income is included in the equations.

A measure of input prices could also in principle impact on industrial demand as it is likely to be related to the general price level. Again, however, the relative size of these industries indicates that this would not be a concern provided that a general measure of price inflation is included in the demand equation.

Despite the theoretical reasons for suspecting endogeneity due to simultaneity bias, it is still worthwhile to test whether this endogeneity can be detected in the data because:

- it is possible that the price is supply inelastic
- it is possible that the impact of endogeneity is so small that it cannot be detected in the data (suggesting that the issue would have minimal effects on the estimated coefficient values)

The Hausman test for endogeneity

It was decided to use the Hausman test to test for endogeneity. The usual interpretation of this test is that under the null hypothesis there is no endogeneity and under the alternative hypothesis there is. However, it is important to note that there are several possible interpretations for the failure to reject the null hypothesis:

- the variable in question is not endogenous
- the variable in question is endogenous but the test gives a false negative (Type II error) for one of the following three reasons:
  - the endogeneity is small and cannot be detected by the test
  - the instruments are weak and hence their effect (which is crucial to the test) cannot be detected by the test

– the variance is too large (perhaps due to sample size) meaning that the test is not sufficiently powerful

There is no easy way to suggest which of these cases applies if the null hypothesis (of no endogeneity) is not rejected. The preferred approach in such cases is to estimate the equation without instruments as the Hausman test suggests that the impact of the instruments on the estimates is small (for any of the reasons given above).

Other sources of endogeneity

Another potential source of endogeneity arises from the possibility of omitted variable bias (or unobserved heterogeneity). Omitted variable bias occurs when there is a correlation between an unobserved component of the equation and an observed component. It leads to biased and inconsistent estimates; the magnitude of the bias depends on the extent of the correlation between the observed and unobserved components.

In the case of this study, potential sources for omitted variable bias can arise from not finding appropriate explanatory variables that reflect cross-country heterogeneity in the demand for products. Factors such as industrial structure and consumer preferences cannot easily be measured and included as explanatory variables. Another potential source of omitted variable bias is heterogeneity over time – in particular, the possibility of symmetric shocks to demand that impact on all Member States.

To deal with this potential problem the fixed-effects technique was used in the econometric analysis. This approach decomposes the unobserved component into Member State-specific fixed effects, period-specific fixed effects and an idiosyncratic shock. Because we have multiple observations for each cross-section (one per time period) and multiple observations for each time period (one per cross-section) we can estimate these fixed effects in an unbiased manner effectively rendering these parts of the unobserved component observed. This greatly reduces the scope for unobserved heterogeneity as it renders observed all cross-country heterogeneity that does not vary over time as well as all heterogeneity across periods that do not vary between Member States.

Heterogeneity, time series persistence and dynamics

The fixed effects method discussed above will only eliminate all cross-country heterogeneity that does not vary over time, but there remains the possibility of some cross-country heterogeneity in the response to prices (ie the elasticities).

In estimating the econometric model we effectively impose a homogeneous elasticity, whereas the true (underlying population) model may have heterogeneous elasticities. If this is the case, the estimates will suffer from heterogeneity bias. Although it is not possible to estimate a separate elasticity for each Member State using the methodology employed in this study, it is possible to estimate separate elasticities for groups of Member States that might be considered to behave similarly. Given the objective of the study is to obtain European elasticities, some heterogeneity bias is perhaps unavoidable.

Temporal heterogeneity and structural breaks

Another potential source of heterogeneity bias arises from structural breaks in price elasticities over time. There is, however, insufficient data to consistently estimate models which allow for such breaks owing to the short length of the time series. An added complication is those structural breaks that do emerge from the data are for only a few Member States and this makes dealing with them even less tractable. This possibility, again, is an unavoidable consequence of the limited availability of data.

Time series persistence and dynamics

A hallmark of typical short time-series analysis of the sort being conducted here is the absence of the treatment of issues of time series persistence (ie stationarity and dynamics). This is justified by the relatively short length of time studied and by the use of period effects (which deal with heterogeneity over time). Given the short length of the time series (13 periods), stationarity tests (in this case, the unit root test) on the residuals from the estimation have been conducted to assess the validity of this approach.

Heteroskedasticity

Heteroskedasticity refers to either differences in the variance of the unobserved component between cross-sections or over time. Heteroskedasticity leads to biased variance estimates which would impact on statistical inference.

The possibility of heteroskedasticity is to some extent mitigated by the estimation of a log-linear model (because taking logs reduces the range of the dependent variable) and the use of cross-section and period fixed-effects which absorb much of the cross-sectional and period unobserved heterogeneity. However, the omission of dynamics makes the presence of serial correlation likely. This suggests that adequate measures must be taken to deal with this issue.

To deal with this potential issue, the White Heteroskedasticity robust method is used to obtain variance estimates (this does not change the coefficient estimates). The particular form of this method used in this study is robust to heteroskedasticity in both the cross-section and time-series dimensions.

Sample size issues

Given the limited availability of data and the relatively small number of cross-sections, the sample size is realistically at its minimum. This is particularly the case given the use of Instrument Variables which require larger samples. This has several consequences:

- it is not possible to conduct sensible investigations into the properties of sub-samples (whether restricted in the cross-sectional or time-series dimension). With more data, it may have been thought desirable to further investigate the possibility of variation in the results between Member States with better data and those with worse data or variation in elasticities over time (structural breaks)
- the variances are larger than would have been the case in larger samples. Larger variances indicate larger uncertainty and so increase the possibility of Type II error (deciding that a coefficient is insignificant when it exists in the true model). It can also lead to coefficient point estimates that appear to be unreasonable, although estimates more in line with expectation might lie within the confidence intervals

4.4 Summary of Estimation Results

There follows an overview of the results from the econometric estimation for the ten sectors covered in this report, and of the difficulties that arose. The results from the econometric estimation were mixed. Table 4.2 summarises the results, and compares them with The Commission’s trade criteria for vulnerability to carbon leakage. The table also notes the appendix chapter for each sector in which we describe the estimation in full detail. Please refer to those appendix chapters for full details on the results surveyed here.

TABLE 4.2: SUMMARY OF SECTOR RESULTS

Sector (Appendix Chapter)	Domestic Output Equation		Import Equation		Export Equation		Commission Criteria	
	Domestic Price	Import Price	Import Price	Domestic Price	Export Price	Import Price	Cost/GVA %	Trade Intensity %
Manufacture of Flat Glass (A)	**-0.65 (0.000)**	N/A	**-0.97**	0.26 (0.140)	**-0.30 (0.080)**	**0.24 (0.070)**	7.11	21.01
Manufacture of Plastics in Primary Forms (B)	-0.41 (0.360)	**0.53 (0.040)**	**-0.41 (0.010)**	N/A	-0.02 (0.860)	**0.42 (0.040)**	2.21	29.52
Casting of Steel (C)	-0.42 (0.343)	0.06 (0.130)	**-1.43 (0.043)**	N/A	-0.18 (0.141)	N/A	2.20	-
Manufacture of Glass Fibres (D)	**-0.19 (0.060)**	N/A	**-0.26 (0.010)**	N/A	**-0.37 (0.000)**	**0.27 (0.010)**	3.37	23.54
Manufacture of Plaster for Construction Purposes (E)	**-0.80 (0.010)**	N/A	**-0.90 (0.000)**	N/A	**-0.56 (0.030)**	**0.37 (0.000)**	1.13	5.69
Manufacture of Other Inorganic Basic Chemicals (F)	**-0.37 (0.016)**	N/A	**-0.32 (0.034)**	N/A	**-0.93 (0.000)**	N/A	<5%	40.56
Manufacture of Bricks and Tiles, etc(G)	N/A	N/A	N/A	N/A	**-1.66 (0.002)**	N/A	5.07	2.69
Manufacture of Agricultural Tractors (H)	N/A	N/A	N/A	N/A	**-0.71 (0.028)**	N/A	>5%<30%	31.10
Manufacture of Motor Vehicles (I)	**-0.34 (0.095)**	0.31 (0.109)	**-0.84 (0.000)**	**0.57 (0.000)**	-0.20 (0.127)	N/A	0.60	28.90
Manufacture of Lime (J)	**-0.87 (0.002)**	N/A	**-0.53 (0.034)**	N/A	**-1.81 (0.000)**	N/A	65.20	2.56
DG Enterprise Studies								
Manufacture of Paper and Paperboard (N/A)	**-0.5 (<0.05)**	**0.9 (<0.05)**	-0.16 (0.220)	0.10(0.611)	-0.7 (>0.1)	N/A	10.20	25.70
Manufacture of Glues and Gelatines (N/A)	N/A	0.2 (>0.1)	**-0.15 (0.045)**	N/A	-2.8 (>0.1)	N/A	0.90	25.90
Manufacture of Ceramic Tiles and Flags (N/A)	**-3.5 (<0.05)**	**2.3 (<0.05)**	**-0.33(0.089)**	**2.37 (0.041)**	**-4.5 (<0.05)**	N/A	>5%<30%	28.60
Basic Iron and Steel (N/A)	**-5.9 (<0.1)**	**0.2 (<0.1)**	**-0.57 (0.023)**	0.30 (0.561)	**-4.2 (<0.05)**	N/A	10.60	32.30

Note(s) : Figures in parentheses are the probability that the true coefficient is zero, based on the t-distribution of the standard error.
Where figures are marked N/A the variable was dropped from the estimation due to poor joint significance and/or because it had an implausible sign or magnitude.
Source(s) : Cambridge Econometrics, DECC, European Commission and DG Enterprise.

Overview of the Results

One of the most striking features of table 4.2 is that there are many gaps in the results, where it was not possible to produce a meaningful or sensible estimation of the parameters. When performing estimations we eliminated parameter estimations that were either insignificantly different from zero, or which were theoretically very implausible (generally, those that had a counter-intuitive positive or negative sign, and or of an implausible magnitude). In many cases, it was not possible to find an equation specification that produced parameter estimates that met these criteria, hence the gaps in the table.

The own-price elasticities are reasonably large

In the case of own-price elasticities, we were able to report significant coefficient estimates for most of the ten sectors in the case of the domestic and import demand equations[65], and for all ten sectors in the case of the export equations. Broadly, these estimations suggest that these sectors are vulnerable to a modest reduction in demand for a given price increase. However, this is not necessarily an indicator of carbon leakage, as the results show that the cross-price elasticities for both the import and domestic equations are often insignificant or dropped from the estimation because of poorness of fit. Therefore the own-price elasticities suggest that demand for the product is simply reduced as a result of a price change. There are a couple of plausible reasons for this. First, product substitution, firms who use the products as inputs are able to use substitute products which are produced by different sectors. Second, demand could be diminished because firms who use the products as inputs are more efficient in their use of the product. Finally it could be that the knock on to final consumers changes the composition of final demand and therefore reduces demand for this specific product. It should be noted that at first glance there appears to be little correlation between The Commission's trade criteria and the estimation results, that is, sectors which are more vulnerable according to The Commission's trade criteria do not necessarily have greater price elasticities.

For most sectors, the own-price elasticities in the domestic demand equation were in the range -0.35 to -0.6, and are therefore high but intuitively plausible. The exceptions were Glass Fibres, for which the elasticity was lower, at -0.19 (0.060)[66], and Plaster for Construction, for which the elasticity was surprisingly high, at -0.80 (0.010), but usable in the model. The price elasticity of import demand was more variable between sectors, but was found to be higher in many cases, close to -1 in the Flat Glass, Plaster for Construction and Motor Vehicles sectors. The outlier was Casting of Steel, which had a very high elasticity of -1.43 (0.043). The estimates of the price elasticity of export demand had an even larger range, including the high results of -1.65 (0.002) for the Bricks and Tiles sector and -1.81 (0.000) for Lime, this is understandable as sector exports are small. Other Inorganic Basic Chemicals, Agricultural Tractors and Lime had large export price elasticities, while there was no significant price response at all for the Plastics sector. We would expect elasticities for export volumes to be greater than domestic elasticities because exports volumes indicate tradability and therefore the importance of locality of the producer to its markets is diminished and price-based switching more likely to occur. Moreover, this suggests that carbon leakage may be significant in sectors where we lose our export market because of a strong own-price elasticity of demand for exports. However, this

[65] The exceptions were Bricks and Tiles and Agriculture Motors, the reasons for which are discussed below.

[66] Figures in parentheses are the probability that the true coefficient is zero, based on the t-distribution of the standard error.

is discussed more in Chapter 7, because it is important to consider the relative size of the industry, and the cost impact placed upon it through its direct and indirect emissions intensity, in combination with our understanding of cost-price pass-though and our scenario assumptions of carbon costs in the rest of the world.

It was difficult to get estimates of cross-price elasticity

The great majority of gaps in the results occur for the cross-price elasticities, that is, the import price elasticity in the domestic demand and export demand equations, and the domestic price elasticity in the import demand equation. This is interesting, as the cross-price elasticity is one of the most important aspects of carbon leakage[67]. There are numerous reasons why the cross-price elasticities were dropped from the reporting of the estimation. Generally, it is possible that the effect of substitute prices on domestic and import demand was difficult to disentangle from the stronger impacts of income and own-price effects. The low sample size possibly exacerbated this problem, as perhaps the two prices considered were heavily correlated. This is important, because if the two prices do not diverge substantially in the estimation period, yet we are using these coefficients to infer whether carbon leakage will occur, we might not capture the full impact. This is particularly relevant to a sector like Steel where the product is a tradable commodity. However, with this important exception aside, it also might suggest that for a number of the sectors analysed imports are not substitutes with domestically produced goods. This result does suggest that carbon leakage (effectively the shift in production out of the EU) might not be a significant problem for many of the sectors analysed. Another plausible explanation is that imports are used only to supplement domestic supply at times when domestic capacity is unable to meet demand; this result is further supported by the impact of income factors on the import and domestic demand equations.

For some sectors the estimates of cross-price elasticities were both significant and sensible. In the case of domestic demand, these sectors are: Plastics in Primary Forms; Casting of Steel; and Motor Vehicles. However, in the latter two cases, the estimate is narrowly insignificant from zero at the 10% confidence level (our cut-off for inclusion in the model), indicating that the impact of import prices is weak. Plastics in Primary Forms have a significant cross-price elasticity of 0.53 (0.040)[68]. In the case of import demand, these sectors are: Plastics in Primary Forms; Casting of Steel; and Motor Vehicles. In the case of export demand, these sectors are: Flat Glass; and Motor Vehicles. Again, the former is narrowly insignificant from zero at the 10% confidence level, but Motor Vehicles has a significant cross-price elasticity of 0.574 (0.000). We can tentatively conclude that the effects of cross-prices are weak and difficult to detect, with two exceptions where the cross-price elasticity is of a large size.

The results from the DG Enterprise report are different

Table 4.2 also reports results for four sectors for which price elasticities were estimated as part of a project for DG Enterprise[69]. Three of these sectors, the exception being Glues and Gelatines, returned statistically significant results. However, it should be noted that the focus of the DG Enterprise report was on developing an assessment methodology. The results for Ceramic Tiles and Flags and

[67] As imports are substitutes for the consumption of domestic goods, we would expect import prices to have positive coefficients in the domestic demand equations, and likewise for domestic price in the import demand equations.

[68] The own-price elasticity was insignificantly different from zero in this sector.

[69] http://ec.europa.eu/enterprise/policies/sustainable-business/climate-change/energy-intensive-industries/carbon-leakage/files/cl_executive_summary_en.pdf

Basic Iron and Steel have very large magnitudes but our reassessment of the price elasticities of demand for these sectors suggests that the results are robust. It is particularly interesting that for Basic Iron and Steel we do not pick up any import substitution in the data and the result seems counter-intuitive, this might be a result of the high degree of product homogeneity which makes it difficult, statistically, to distinguish between domestic and import price effects. The results for Paper and Paperboard, are broadly in line with the later estimations and have a good fit.

Major difficulties and themes in the results

Below, we discuss some of the major themes and difficulties that arose during the estimations, how they were dealt with, and how this impacted the results. While this provides a broad overview, the detail varies greatly between sectors, and this is discussed in full in the relevant appendix chapters.

There were many gaps in the data

There were many problems with the quality and completeness of data for all sectors, especially at the 4 digit level[70]. In particular, in all cases the domestic price and the producer price index data had many gaps at the four and three-digit levels, and for some Member States even at the least-detailed two-digit level. A number of sectors had around 70-80% of these data missing at the four-digit level. Therefore, in all cases most of the domestic and producer price data were supplemented using the two-digit level data. This is a concern of note, but, since all sectors have roughly the same level of coverage, there is no way of checking how this might have impacted on the results. We therefore suggest that the elasticity results used in the model are taken to be indicative. Moreover, we remain confident that our approach to dealing with missing data; by either dropping some Member States with no data or very small volumes, or by using proxy price series, was the best way to estimate elasticities.

The exception was the Agricultural Tractors sector, which had no data at all for many of these variables at the four-digit level (probably because of the size of the sector). The estimation results for this sector were poor and spurious, and this was probably due to the poor quality of data.

The data for other variables were generally far better, although the domestic output, employment and wages data were around 10% missing at the four-digit level for most sectors: the solution was usually to exclude one or two Member States where production was negligible, rather than fill missing data points[71], as we do not have as much confidence in filled data. The exceptions were the Plastics and Plaster sectors, which had around 30% of these data missing, but the extent to which this impacts on the results is not clear. Less frequently data were also excluded for appearing spurious and, in particular, where demand was zero[72]. Again, since this was the case for all sectors, it is difficult to know how it impacted the results.

Instrument variables were not required in many cases

As discussed in the methodology section, there are powerful theoretical arguments for believing that all three demand equations are likely to be endogenous. However, it was actually found that, in many cases, the Hausman test actually failed to reject the hypothesis that there was no endogeneity. In all cases where this occurred, the instrument variables were dropped, and the estimation continued using Ordinary Least

[70] Two sectors, Bricks and Tiles and Motor Vehicles, are NACE three-digit sectors, and so the three-digit data were the most detailed available.

[71] All data for a particular country were excluded, rather than only excluding some data from a particular country.

[72] Estimations over periods where the production data are zero can lead to biased estimates.

Squares. Interestingly, for the most part, these estimations returned plausible and usable results.

When instrument variables were used, it was found that the producer price index was generally the most useful instrument, as its use was associated with more plausible and significant estimates of price elasticity. This is unsurprising because it captures all aspects of costs rather than simply labour costs which are captured by the other instruments we tested and many of the sectors investigated are capital intensive sectors.

The fixed effects were usually significant

Other tests on the equation specification produced mixed results. For the most part, the use of fixed effects, both across countries and across time was vindicated by the diagnostic tests. This suggests that there is considerable unobserved variation both across time and between countries. However, hypothesis tests on the residuals show that there are dynamic effects that were not successfully accounted for (there is autocorrelation in the residuals). This is not entirely surprising, as we deliberately decided not to try and account for dynamics due to the short time series of the data.

Heterogeneity within sectors was a problem in some trade equations

While fixed effects controlled for the heterogeneity between countries and time periods, there was no way of controlling for the heterogeneity within sectors (ie a sector is made up of many different goods, each with their own demand schedules). As noted in the methodology section, there was no way of controlling for this, and some unknown level of aggregation bias is to be expected. However, it was found that the trade price data, specified in €/100kg, was inappropriate for sectors with a large amount of product heterogeneity with respect to a weight-value ratio. In cases where this was suspected, we attempted estimation of the trade equations using a two-digit level price index from E3ME; in the case of Basis Inorganic Chemicals and Motor Vehicles (which is a single aggregate sector identified in E3ME), these versions of the equations were used as the final result. The use of these price series did not improve the results for the Agricultural Tractors sector, although the poor results for this sector, with respect to price, were more likely to be driven by the poor demand volume data.

In many cases, it was found that income was the main driver of demand

Finally, one of the main reasons for difficulties in estimating significant price coefficients was that, in many sectors, the demand was driven predominantly by income. This was particularly the case for the Bricks and Tiles sector and, to some extent, the Agricultural Tractors sector[73], where estimation of the own-price or cross-price elasticities produced spurious and insignificant results, since demand was overwhelmingly driven by income. Income was also found to be an important driver in the Plastics, Glass Fibres, Plaster Products, Other Inorganic Basic Chemicals and Motor Vehicles sectors. This is one of the key results of the analysis as it suggests that demand is predominantly driven by (macro) income factors rather than price and carbon leakage impacts might therefore be expected to be small. This is discussed further in Chapter 7.

[73] Although in this case, problems with the data caused most of the problems with estimation.

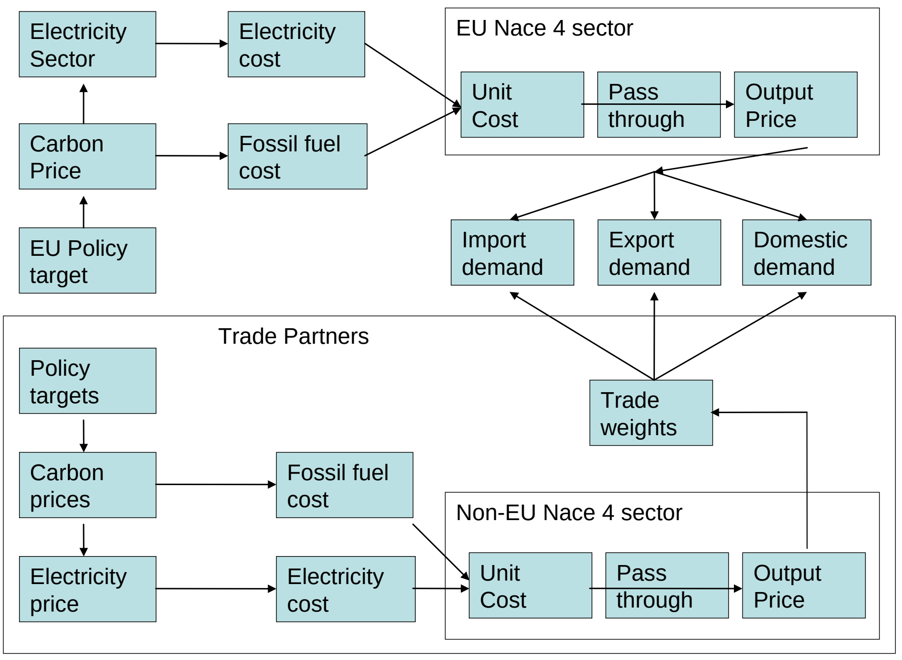
5 Model Design and Assumptions

This chapter describes the structure of the sector modelling tool used to perform the scenario analysis, as well as the assumptions that underpin the tool. There are two main sections to this chapter: the first describes the structure of the model; the second explains the underlying assumptions and their implications for the analysis.

5.1 Model Structure

Having established for each scenario the carbon prices in the EU27 and its main trading partners (discussed in Chapter 6), the purpose of the model is to translate the mitigation efforts into cost and then price increases. Applying the price elasticities estimated in the econometric analysis (Chapter 4) yields estimates of the change in demand for goods produced in the EU27 (domestic and extra-EU export demand) and abroad (extra-EU import demand). The model also produces estimates of the subsequent change in emissions in the EU27 and its trading partners to indicate the potential emissions leakage as a result of the shift in production. The figures are intended to be indicative of the carbon intensity of the production shift. The emissions changes do not reflect carbon leakage, per se, but rather the emissions shift as a result of the production shift.

Figure 5.1: Sector Framework Outline



The model's parameters are based heavily on the results of The Commission's impact assessment to identify sectors at risk of carbon leakage

The model's parameters are based heavily on the results of The Commission's impact assessment to identify sectors at risk of carbon leakage[74]. The estimates of the sector impacts (in terms of GVA) were combined with data from Eurostat to estimate the direct (from carbon costs) and indirect (from carbon costs feeding through to electricity prices) impacts on producer costs of carbon pricing.

The model is capable of accounting for differences in the emissions intensity of electricity between the EU27 and the trading partners identified in the model. The extra-EU import price of goods is formed as a weighted average of each country's change in price, based on the value of trade.

Pass-through rates from CE's E3ME[75] model by broad (NACE two-digit) sector are then applied to calculate the increase in the price faced by end users.

The price elasticities estimated in the econometric analysis are then used to determine the change in demand (as discussed below).

We have translated the carbon targets of the main trading partners for each sector into carbon mitigation costs…

The policy targets of each trading country and of the EU itself have been translated into increases in sector costs. First, the project team in partnership with DECC has assessed the carbon prices that are assumed to be required to achieve each trading country's policy target in each scenario. For example, in the case of the EU's 20% target, we have used a carbon price of €30/tCO_2, which matches that in The Commission's own analysis and identification of sectors at risk of carbon leakage[76]. The carbon price assumptions for each scenario are discussed in Chapter 6.

… and calculated its impact on fossil fuel and electricity costs…

This carbon cost can then be translated directly into increases in production costs. For electricity however, we will first need to model the unit cost increase in the electricity sector, based on the carbon intensity of electricity, and then make an assumption on how much of the cost increase is passed through to customers, based on our assessment of the regulatory structure of the industry in each trading partner. The standard assumption is that costs are fully passed through to electricity prices, but the model has been constructed in such a way that the user is able to alter this assumption for the EU27 and the individual trading partners. The model is a comparative static model and so we assume that the generation mix remains unchanged. This is justified though, as the marginal cost of mitigation will be equal to the carbon price and, for the electricity sector at least, is expected to be passed on to consumers (again, depending on the regulatory regime).

Pass-through rates come from CE's E3ME model

Having derived the increases in producer costs, the model must then translate the cost increases into price increases. We have used sector pass-through rates from CE's E3ME model, specifically, the long-term elasticities relating unit cost to output price. It should be noted that these elasticities are estimated at a broader, two-digit level of aggregation than the NACE four-digit sectors actually included in the model. However, because of uncertainty around these estimates and in light of the goal to produce a robust, transparent modelling framework for DECC, the assumptions are easily changed in the model.

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[74] http://ec.europa.eu/environment/climat/emission/pdf/proportionate_ia_%20leakage_list16sep.pdf

[75] Energy-Environment-Economy Model of Europe. For more details, see http://www.e3me.com

[76] http://ec.europa.eu/environment/climat/emission/carbon_en.htm

Trade weights are used to estimate price changes relative to the EU

The method just described can be directly applied for the EU27 (ie the impacts on domestic and export demand), but the impact of potentially-varying climate-change mitigation action in EU trading partners must be combined into a single, weighted import price, as we are using pooled trade data rather than a much more complex multilateral trade system. This was done using detailed data on trade to form trade weights.

The demand elasticities are then applied to infer the economic production leakage, which in turn can be translated into carbon leakage

The final stage is to apply the price elasticities of demand for (EU) imports, exports and domestic demand, to obtain the estimate of how demand (and therefore production) will change domestically and shift abroad in response to the changes in output prices. The sector-specific price elasticities of demand, and the method for obtaining them, are discussed in the previous section. Historical carbon intensities, based on 2007 data, of sector output are calculated in the model and used to translate changes in demand into changes in emissions.

5.2 Assumptions and limitations of modelling approach

The model requires a number of input assumptions

It is important to be clear about the assumptions behind, and limitations of, any modelling approach. The model requires a number of assumptions. The model clearly states the sources of all its inputs and these assumptions have been implemented in such a way that they can be easily changed at a later date.

The project team agreed the carbon prices for each scenario with DECC…

The first set of input assumptions is the price of carbon (or associated cost of carbon mitigation action) in the EU and each of its main trading partners.

As a starting point, the project team used The Commission's suggested €30/tCO_2 carbon price for modelling the EU's commitment to cut GHGs by 20% by 2020. The project team then clearly specified a set of carbon prices for each scenario and each trading partner. This was based on an assessment of the pledges submitted by signatory countries to the Copenhagen Accord and supplemented by input from DECC experts. The carbon prices are discussed in more detail in Chapter 6 on scenarios, but it is important to recognise that the carbon prices are stylised assumptions designed to represent fairly broad-brush post-Copenhagen mitigation scenarios.

…and these are easily modified

The carbon prices under each scenario are easily changed. Moreover, the model has the facility for introducing a 'custom' scenario so that new scenario inputs can be inserted without having to replace an existing scenario.

Cost pass-through rates were taken from CE's E3ME model

The other main set of assumptions used is the extent of cost pass-through for each sector (see Table 5.1). The rates currently implemented in the model are taken from CE's E3ME model at a broader level of sector disaggregation and, again, are easily updated. The main limitation of using historical estimates is the assumption that the same relationship between cost and price will hold in the future. In other words the cost impact from the EU ETS is the same as any other cost impact. However, this limitation can be considered true of any econometrically-derived estimate.

Free allowances have been modelled as an impact on direct costs

To model the impact of free allowances, we will adjust the direct cost impact of carbon pricing to reflect the new level of free allocations (The Commission's impact assessment figures used assume 75% auctioning). The implication is that the cost impact of differing levels of free allocation is passed on to consumers in the same manner as any other change in costs; firms do use free allowances to reduce cost pass-through. However, it is plausible that firms will still choose to pass costs on and retain supernormal profits. Clearly though, it seems unlikely that a firm would do this if there was a risk of losing production to other more competitive world regions. Hence, from a policy perspective, this assumption still explains the impact on carbon leakage of free allowances. Moreover, it will provide an insight as to the impact of carbon leakage caused *indirectly* from increased electricity costs, versus the *direct* impacts, as free allowances will only be given to installations directly emitting carbon.

It is assumed that extra-EU sectors have the same energy cost structure as the EU counterpart

It is outside the scope of the project to model the trading partners in as much detail as the EU, and incorporating them into the model has required a number of simplifying assumptions. This is partly driven by our knowledge and understanding of the data for the 43 trading partners we have identified. We assessed the top ten sources of origin and top ten destinations for each sector. In most cases this was sufficient to account for at least 80% of trade in each sector, a benchmark deemed adequate for the analysis.

We have also made the stylised assumption that each trading partner has the same basic input cost structure, in terms of energy use, as its EU counterpart. Clearly, this will not necessarily be a realistic assumption in all cases but, given the detailed level of sector disaggregation, it seems to be a more justifiable assumption that, at the NACE four-digit level, sectors are more similar in terms of cost structure across regions than they are within the broader parent NACE two-digit sector, for which some data are available (but not all). In other words, we assume, for example, that the Casting of Steel NACE four-digit level sector has the same energy-intensity in the US as the EU, because the alternative (given the data), is to assume that Casting of Steel in the US has the same energy intensity as its parent NACE two-digit sector Basic Metals in the US.

However, to improve the suitability of the inputs, the carbon intensity of electricity is allowed to vary by region as the data are known to be both robust and available (from the IEA). The assumption raises a secondary policy issue as to whether industry should be protected if it is substantially worse performing (in environmental terms) than a foreign counterpart. This issue, while clearly important, is beyond the scope of this analysis.

The model is a comparative static model and dynamic effects are ignored

The model assumes that sectors cannot reduce energy demand in response to increases in energy prices as a result of a carbon price, or rather, if they can it is at a cost equivalent to the carbon price. This is in line with the EU ETS policy which suggests that firms will take action up to the point where the carbon price is equal to the system-wide marginal cost of abatement. As such, this assumption seems valid as long as the assumed carbon price is realistic. However, the model is a comparative static model and, as such, does not show the impact of dynamic changes occurring in the economy as a result of EU ETS policy. For example, investment in CO_2 abatement equipment may reduce future costs more substantially due to economies of scale than anticipated in our stylised assumptions. Again, this assumption seems valid if the carbon price used is realistic.

Global fossil fuel prices are assumed not to change

It is also assumed that energy prices do not change in response to climate change mitigation action. This could potentially be true of large scale action as anticipated in some of the scenarios as reduced energy demand puts downward pressure on the price of fossil fuels.

Complex whole economy interactions are ignored, with a focus on 'first-round' sector impacts

Trade relationships are based on pooled trade, as this is how the elasticities are derived and is most suitable given the data that are available. Furthermore the impact on secondary sectors, through changing international supply chains, and the impact of increased supply-chain costs are not taken into account. Other whole economy effects such as price inflation leading to wage inflation, which would result, other things being equal, in the EU being generally more price uncompetitive, are also not considered, as they are beyond the remit of this study. A whole economy modelling approach is required to estimate the full impacts; the sector model is designed to focus in detail on the first round impacts of higher fossil fuel costs, and higher electricity costs as a result of carbon mitigation policy. Once again, this limitation is driven by data sufficiency as we do not know the input-output relationships and interactions at this level of sector detail.

Assumptions and limitations are driven by data availability and the scope and focus of the project

Finally, many of the limitations in the model are due to a lack of data and/or reliability. The data and assumptions are, ultimately, all sourced from Eurostat.

The project team is aware that Eurostat data is regularly challenged by stakeholders, particularly from industry as not adequately reflecting the business reality. However, while these data are often challenged, suitable alternatives are scarcely ever offered, and third party data sources are often inadequate, either because the coverage is not complete, or because the data are not consistent across the various dimensions required for this study.

Our assessment of the robustness of the price elasticity of demand estimates, in light of the data used, is discussed in Chapter 4 (Section 4.4) and should be considered when interpreting the full model results, discussed in Chapter 7.

TABLE 5.1: COST PRICE PASS-THROUGH ASSUMPTIONS

	Pass-through	E3ME Sector
Manufacture of paper and paperboard	0.63	Wood & Paper
Manufacture of other inorganic basis chemicals	0.69	Chemicals nes
Manufacture of plastics in primary forms	0.69	Chemicals nes
Manufacture of glues and gelatines	0.69	Chemicals nes
Manufacture of flat glass	0.58	Non-metallic Mineral Products
Manufacture of glass fibres	0.58	Non-met. Mineral Products
Manufacture of ceramic tiles and flags	0.58	Non-met. Mineral Products
Manufacture of bricks, tiles, etc	0.58	Non-met. Mineral Products
Manufacture of lime	0.58	Non-met. Mineral Products
Manufacture of plaster products for const.	0.58	Non-met. Mineral Products
Manufacture of basic iron and steel, etc	0.84	Basic Metals
Casting of steel	0.84	Basic Metals
Manufacture of agricultural tractors	0.19	Mechanical Engineering
Manufacture of motor vehicles	0.94	Motor Vehicles

Source(s) : E3ME database, Cambridge Econometrics.

6 Scenario Design

6.1 Introduction

This chapter outlines the scenarios modelled in our analysis

This chapter describes the scenarios modelled by the project team as part of the project. We developed four key scenarios for analysis, and each scenario is based upon different GHG mitigation targets for the trading partners of the sectors selected by DECC.

The scenarios are:

- Reference Scenario
- Copenhagen Accord Low Offers
- EU Stretch, Copenhagen Low
- Copenhagen High

We believe that the first two scenarios are at the heart of the analysis, while the latter two scenarios are more indicative of additional mitigation action which has been suggested but has not yet been agreed upon by policy makers.

We first developed a 'worst-case' (ie with respect to the risk of carbon leakage) Reference scenario upon which the Copenhagen Accord Low Offers scenario was developed. The subsequent scenarios vary from this Copenhagen Accord Low Offers projection depending on the greenhouse gas (GHG) abatement targets set out by the EU compared to its key trading partners in the sectors analysed. This allowed us to assess the level of carbon leakage that may arise under different paths of emissions reduction.

Table 6.1 summarises the main features of the five suggested scenarios.

TABLE 6.1: SUMMARY OF SCENARIOS

Scenario	EU mitigation target	EU carbon price	Extra-EU mitigation target
Reference Scenario	20% reduction in GHGs	€30/tCO2	No mitigation
Copenhagen Accord Low Offers	20% reduction in GHGs	€30/tCO2	Copenhagen Accord pledges
EU Stretch, Copenhagen Low	30% reduction in GHGs	>€30/tCO2	Copenhagen Accord pledges
Copenhagen High	30% reduction in GHGs	>€30/tCO2	Copenhagen Accord pledges (+)

Source(s) : Cambridge Econometrics.

We have modelled policy sensitivities on each of the main scenarios

In addition, for the Copenhagen Accord Low Offers we analysed the impact of free allocation and Border Adjustment Mechanism (BAM) policies[77], by providing a series of accompanying sensitivity results (see Chapter 7). This will help guide policy decisions in each scenario, and will enrich the comparisons between the scenarios. A further sensitivity was examined with respect to electricity price pass-through to the sectors under analysis, as we know that in some regions electricity price regulation prevents full price pass-through and this may have a substantial impact on the results. As it proved impossible to get a sensible set of pass-through rates for each of the 43 regions, we have provided a range of results from 100% pass-through in the core results to no pass-through in the sensitivity analysis.

6.2 Main Scenarios

Reference Scenario

In the Reference scenario, the EU honours its commitment to a 20% reduction in greenhouse gas emissions by 2020. However, the rest of the world does not take any action to reduce carbon emissions, and does not honour the targets pledged by countries signatory to the Copenhagen Accord. The project team has modelled the EU's commitment at a carbon cost of €30/tCO_2, which matches that in The Commission's own analysis and definition of sectors at risk of carbon leakage[78]. The cost base for non-EU trading partners will not be adjusted to account for a carbon price.

This scenario is primarily intended as a point of comparison to the other scenarios, by estimating carbon leakage under the most adverse conditions for EU firms. Comparison with the Copenhagen Low scenario (see below) would indicate how action by the rest of the world will reduce the amount of carbon leakage in the most vulnerable sectors through smaller disparities in competitiveness arising from GHG abatement action, thereby illustrating the benefits of coordinated action on GHG emissions.

This scenario can be considered a worst-case scenario with respect to carbon leakage. It is not yet entirely implausible, given that most of the pledges submitted to the UNFCCC under the Copenhagen Accord are not yet legally binding, and in many cases the policies to realise them are not in place

Policy relevance

The policy relevance of this scenario is to test the degree of carbon leakage, for the chosen sectors, under the worst case scenario of unilateral EU action, whereby only the EU faces mitigation costs at €30/tCO_2.

Copenhagen Accord Low Offers

Building on the Reference scenario, in the Copenhagen Accord Low Offers scenario the EU honours its commitment to a 20% fall in greenhouse gas emissions by 2020, and the rest of the world honours the commitments announced as part of the Copenhagen Accord. Again, we have modelled the EU's commitment as a carbon cost of €30/tCO_2. For the rest of the world, the project team analysed the targets for each of the 43 trading partners identified (see Table 6.2), and translated the targets into a carbon cost increase for each sector, accounting for both *direct* and *indirect* costs. This was done in agreement with DECC and depended on the ambition of the targets relative to the EU.

[77] The results of the sensitivities were only reported for the EU stretch - Copenhagen Low scenario for simplicity.

[78] http://ec.europa.eu/environment/climat/emission/carbon_en.htm

This scenario matches the likely current state and effect of the international negotiations over GHG-emissions abatement, and in this sense could be considered the central baseline for the project. This scenario gives an estimate of the extent of carbon leakage if the present international GHG-reduction target situation does not change, and its outputs will be a key input for current policy on sectors at risk of climate change, and on free allocation and BAMs sensitivity analysis.

As the baseline, this scenario will serve as a key point of comparison for the other post-Copenhagen scenarios (the targets/pledges submitted to the UNFCCC as part of the Copenhagen Accord are not set in stone and may change). A comparison between the alternative scenarios and this Copenhagen Low scenario will indicate how carbon leakage will be affected by the outcomes of future negotiations on international GHG abatement.

Policy relevance

The policy relevance of this scenario is to test the degree of carbon leakage, for the chosen sectors, under the most likely outcome to date, as highlighted by the pledges under the Copenhagen Accord. The team has translated the Copenhagen Accord pledges into a carbon price for each sector's top ten trading partners, and modelled this for each sector compared to the €30/tCO_2 EU carbon price.

EU Stretch, Copenhagen Low

In the 'EU stretch' scenario, the EU increases its target to a 30% reduction in GHG emissions by 2020, but the rest of the world takes no further action beyond that already pledged as part of the Copenhagen Accord (ie those actions in the Copenhagen Low scenario). The project team has kept the carbon cost estimates from the Copenhagen Low scenario for the rest of the world unchanged, and has revised the EU's €30/tCO_2 price upwards to €40/tCO_2.

At present, the EU has signalled its willingness to tighten its GHG abatement target to 30%, but it is choosing to retain the option for future negotiations at the present time. This scenario would model the situation in which the EU is unable to extract any further GHG abatement targets from the rest of the world, but chooses unilaterally to upgrade its own target in any case, perhaps because the impact of the 2008-09 recession in reducing emissions has made the 20% target easier to achieve (alternatively, it models the scenario in which the EU is forced to upgrade its target to secure the existing commitments from the rest of the world).

A comparison of this scenario to the Copenhagen Low scenario will indicate by how much carbon leakage would be exacerbated by unilateral EU action, and policy could be adjusted in response. A comparison of the EU Stretch scenario to the below scenario (global stretch ambition) will inform how closely the EU's proposed 30% target should be conditional on extracting further targets from the rest of the world, from the carbon leakage perspective.

Policy relevance

The policy relevance of this scenario is to test the degree to which carbon leakage is worsened, for the chosen sectors, under the most likely outcome to date but with additional unilateral commitment from the EU to the 30% target.

Copenhagen High

The EU increases its target to a 30% fall in GHG emissions by 2020, and given this, the rest of the world sets targets for 2020 that are at the top range of the commitments made under the Copenhagen Accord. The EU carbon price from the EU Stretch scenario will be carried over to this scenario. For the rest of the world, the project team have devised a plausible set of country targets that are sufficient to achieve something broadly akin to the 2°C target[79], broadly based on Copenhagen high end offers (with interpretations for a number of countries who have not made any such offer yet), and then translated into sector carbon prices.

Therefore, this scenario models the situation in which future negotiations over GHG abatement are successful for the EU. It is most plausible that, in order to secure further commitments from the rest of the world on GHG abatement, the EU would have to have raised its own target to the 30% level.

This scenario shows how carbon leakage would be affected, and also how the use of free allocation and BAMs (in the subsequent sensitivity analysis) would be affected, if the EU were to achieve its objectives in future GHG abatement negotiations. A comparison with the Copenhagen Low scenario indicates whether or not this success in negotiations would be achieved at a cost or benefit to the carbon leakage problem, while a comparison with the EU Stretch scenario would demonstrate the importance, or otherwise, of securing increased GHG abatement targets from the rest of the world if the EU is to increase its own target to 30%.

Policy relevance

The policy relevance of this scenario is to test the degree, to which carbon leakage is reduced, for the chosen sectors, if additional EU unilateral action is broadly matched.

A full set of scenario carbon prices is provided in Table 6.2. It should be noted that in cases where the carbon price for a region is zero this does not necessarily represent a view that no carbon mitigation action will be taken in that region. Rather we have provided a pessimistic/conservative estimate in light of little, or unclear, information. By employing a conservative estimate the impacts on EU production can be considered the worst case impact, as estimated by this framework.

[79] There is considerable uncertainty over the necessary GHG emissions pathways to meet global temperature target. The purpose of the scenario is not to identify this, but to use stylised assumptions on carbon targets and carbon prices which are beyond the current ambitions as stated in the Copenhagen Accord.

TABLE 6.2: CARBON PRICE SCENARIO ASSUMPTIONS

Country	Current Target (GHG uos)		Baseline Year	Comments	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	High	Low			€/tCO_2	€/tCO_2	€/tCO_2	€/tCO_2
EU	-20	-30	1990		30	30	40	40
United States	-17	-17	2005		0	15	15	15
Switzerland	-20	-30	1990		0	30	30	40
Japan	-25	-25	1990		0	30	30	40
Turkey				no communication	0	0	0	0
South Africa	-34	-34	compared to a BAU		0	10	10	10
Hong Kong				no communication	0	0	0	0
Taiwan				no communication	0	0	0	0
Brazil				nothing that is likely to affect the 14 industries	0	0	0	10
Norway	-30	-40	1990		0	30	30	40
South Korea	-30	-30	compared to a BAU		0	10	10	10
China	-40	-45	2005	CO_2 as a ratio of GDP	0	0	0	10
Russia	-15	-25	1990		0	0	0	0
Israel	-20	-20	compared to a BAU	mostly through electricity demand/supply	0	10	10	10
Chile				no communication	0	0	0	0
United Arab Emirates				no communication	0	0	0	0
Serbia				no communication	0	0	0	0
Indonesia	-26	-26	not stated		0	10	10	10
Thailand				no communication	0	0	0	0
Mexico	-30	-30	compared to a BAU		0	10	10	10
India	-20	-25	2005	CO_2 as a ratio of GDP	0	0	0	10
Ukraine	-20	-20	1990		0	0	0	0

TABLE 6.2: CARBON PRICE SCENARIO ASSUMPTIONS (CONTINUED)

Country	Current Target (GHG uos)		Baseline Year	Comments	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	High	Low			€/tCO_2	€/tCO_2	€/tCO_2	€/tCO_2
Canada	-17	-17	2005		0	15	15	15
Malaysia				no communication	0	0	0	0
Croatia	-5	-5	1990		0	10	10	20
Saudi Arabia				no communication	0	0	0	0
Albania				no communication	0	0	0	0
Singapore	-16	-16	compared to a BAU		0	10	10	10
Bosnia and Herzegovina				no communication	0	0	0	0
Serbia and Montenegro				no communication	0	0	0	0
Macedonia	-17	-30	compared to a BAU		0	10	10	20
Lebanon					0	0	0	0
Egypt					0	0	0	0
Australia	-5	-25	2000		0	30	30	40
New Zealand	-10	-20	1990		0	30	30	40
Belarus	-5	-10	1990		0	10	10	20
Iran				no communication	0	0	0	0
Ghana				not quantifiable	0	0	0	0
Yuogslavia				no communication	0	0	0	0
Guinea				no communication	0	0	0	0
Cote d'Ivoire				not quantifiable	0	0	0	0
Tunisia				no communication	0	0	0	0
Colombia				no communication	0	0	0	0
Dominican Rebuplic				no communication	0	0	0	0

Source(s): UNFCCC, DECC and Cambridge Econometrics.

6.3 Sensitivity Analysis

The sensitivity analysis[80] is designed to test the impact of various policies on the model results and to test the assumptions of the model. In total four sensitivities were developed with DECC and the results are reported in Chapter 7, the sensitivities were:

- 80% free allocation of EU ETS permits
- 50% free allocation of EU ETS permits
- Border Adjustment Mechanisms (BAMs)
- electricity price regulation

Free allocation of EU ETS permits

The first two sensitivities have been modelled by making the stylised assumption that the free allocation of EU ETS permits reduces costs to the sector and prevents costs from being passed on. However, this is clearly stylised, because profit-maximising sectors (firms) actually face the same economic incentives to pass costs on, whether they are compensated for them or not. This stylised assumption is valid, though, in the sense that if a firm/sector is at risk of considerable carbon leakage and its short term incentive is to maintain production levels and market share rather than maximise its profits, it is rational to assume that the free allocation of EU ETS permits would be used to offset cost pass-through and therefore maintain production.

Border Adjustment Mechanisms

Border Adjustment Mechanisms (BAMs) are designed specifically to prevent carbon leakage (shifts in production) by equalising import prices, through the application of a border tax, with domestic prices by applying the same cost the domestic industry faces to imports[81]. We have assumed that an administrator would have perfect information to do this, and so the sensitivity analysis is modelled by removing the carbon cost differential from import prices. We have also assumed that the border adjustment is full, in other words it equates imports by increasing imports such that the implicit carbon cost differential is effectively zero. To this end, the results discussed in Chapter 7 illustrate the maximum impact. The policy intervention impacts on domestic demand for domestic production, and import demand (but not export demand) depending on the price elasticities derived as part of the econometric investigation reported in Chapter 4.

Electricity price regulation

DECC asked that we assess the impact of electricity price regulation within the modelling framework. As discussed in Chapter 5, the model takes into account both *direct* carbon costs, and *indirect* carbon costs on the basis of electricity consumption. However, it is clear that some of the trading partners (and some Member States in the EU) have highly restrictive electricity price regulation regimes. This suggests that the cost of carbon mitigation will not be passed onto final industrial electricity consumers. We were unable to obtain a full set of pass-through coefficients for each of the 43 trading partners modelled as part of this exercise. As such, we have used this sensitivity to provide a range of results, in the main scenario results electricity prices are passed through in full to the sectors under investigation, whereas, in this sensitivity, we assume that electricity prices outside the EU are regulated. The results of this sensitivity, therefore, show the upper and lower bounds of the impact of electricity price regulation on carbon leakage in the 14 sectors.

[80] The sensitivity analysis was applied to the Copenhagen Accord Low Offers scenario. The results, however, can be interpreted as broadly true across each of the sectors, and the general findings are certainly true across all scenarios.

[81] BAMs can also be used to subsidise export prices, but we have not modelled this option

7 Assessing the Degree of Carbon Leakage

7.1 Introduction

This chapter presents the results from the modelling framework. The first section describes the impact of the different carbon prices in each scenario in terms of the change in EU demand for its own domestic production and imports from the rest of the world; and of demand for EU production from the rest of the world. Our metric for carbon leakage in this report is therefore the shift in production through import substitution, loss of export markets, and indicatively by a reduction in domestic demand and losses in EU production. The implied impact on emissions, through changes in production, is also discussed.

The remaining three sections present the results of the sensitivities run, in which alternative policies (differing levels of free permit allocation and Border Adjustment Mechanisms [BAMs]) and differing levels of electricity price regulation (ie electricity price cost pass-through) are assessed.

7.2 Scenario Results

In the Reference scenario, the carbon price causes EU production in most sectors to fall by less than 1.5%

The Reference scenario models the situation in which the EU commits to its 20% GHG emissions reduction but the rest of the world makes no emissions-reduction pledge. In this scenario, EU sectors face a carbon price of €30/tCO_2. The carbon price, for the majority of the sectors identified in the model, leads to production cost increases of less than 5%[82] with the highly energy-intensive sectors Manufacture of ceramic tiles and flags[83] (ceramics) and Manufacture of lime as notable exceptions (cost increases of 12.4% and 23.6% respectively). Applying the cost pass-through rates of the broader NACE two-digit level sectors from CE's E3ME model leads to increases in the price of EU-produced goods (for both domestic and overseas consumption) of 3% or less with the aforementioned sectors as exceptions (increases of 7.2% and 13.7%). The assumption of no additional action by the rest of the world means that the price of extra-EU imports is unchanged.

We do not model the affect of diminished profit if costs are not passed on

While we have applied pass through rates based on historical estimates, it should be noted that the modelling results only reflect production shifts as a result of price changes and demand responses. If costs are not passed on, then profits are likely to be diminished and this might impact on the long term investment prospects of the sector. It might also divert investment outside the EU to sectors not facing carbon abatement costs.

Applying the price elasticities (own price and cross price elasticities) estimated previously (see Chapter 4) to the price changes suggests that demand for EU-produced

[82] Cost increase as a proportion of total production costs rather than GVA, as such these figures do not match the EC figures, but are consistent with The Commission's criteria figures. Production costs are defined as the sum of all input costs including wages and salaries.

[83] The production-cost increase as a percentage of GVA for Manufacture of ceramic tiles and flags was given as a range in The Commission's impact assessment of more than 5% but less than 30%. In the model, the 30% figure has been used. The same is true of Manufacture of agricultural tractors.

goods for both domestic and foreign consumption (and thus production) falls by less than 1.5% for all but:

- Manufacture of ceramic tiles and flags (-15.1%)
- Manufacture of lime (-12.1%)
- Manufacture of basic iron and steel and of ferro-alloys (iron and steel) (-11.6%)

In the case of ceramics, the reduction in demand is explained by the relatively large increase in cost and price compounded by a domestic price elasticity of demand with an absolute value greater than unity. The estimated export price elasticity of demand is also substantial (-4.49) and this leads to a large fall in extra-EU demand that is, in levels, greater than the reduction in EU demand for domestic production.

The reduction in demand for EU production of lime is the result of relatively high price elasticities such that the cost increase yields an almost like-for-like reduction in domestic demand (the elasticity was estimated to be -0.87). The overall 12.1% reduction in demand for EU production arises because of the high export price elasticity (with an absolute value greater than one), despite the low trade share of this sector vis-à-vis the rest of the world.

The substantial reduction in demand for EU-produced iron and steel, despite the comparatively low price increase of 2.1% can be attributed to the high price elasticities estimated for this sector; both the domestic and export price elasticities of demand far exceed one in absolute value.

EU demand for goods in the Reference scenario falls overall

Because the rest of the world is not assumed to be taking any additional climate change mitigation action in the Reference scenario, the change in demand for imported goods from the rest of the world by EU Member States arises through the increase in domestic prices (the price of the good that competes with extra-EU imports). The cross price elasticities for the sectors identified in the model are in many cases zero, indicating no substitution, or low compared to the import price elasticity, suggesting appreciable product differentiation. As such, demand for goods produced in the rest of the world in response to more expensive EU-production increases by less than 1.5% and not at all for the majority of sectors (see Table 7.1). The exception is ceramics which, as previously mentioned, sees a substantial cost increase that is compounded by a very high estimated cross-price elasticity of 2.37. This leads to a 17% increase in import demand. In levels, this is not a large increase because the volume of ceramics imported by the EU from the rest of the world is small as a share of domestic production.

The result is that the increase in demand for imported goods is much smaller than the decrease in demand for domestically-produced goods (in level terms). This result is driven by the estimated price elasticities, which find little evidence for import substitution. Total EU demand by sector falls in this Reference scenario, which assumes unilateral EU mitigation action. This fall in EU demand is outweighed by the fall in EU production.

Production in the rest of the world must increase to meet both EU and extra-EU demand

The Reference scenario does show some switching in EU demand, from EU production to the rest of the world. Production in the rest of the world must, consequently, increase to meet the additional demand.

Moreover, the model assumes that total demand from the rest of the world does not change, only the source of supply. The result of this is that if the model indicates a reduction in extra-EU export demand, this quantity of demand must be met in the rest

TABLE 7.1: DEMAND IMPACTS IN THE REFERENCE SCENARIO

	€m			%			
	Domestic	Import	Export	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-457	75	0	-0.8	1.4	0.0	-0.6
Manufacture of other inorganic basic chemicals	-182	0	-47	-0.8	0.0	-1.9	-0.9
Manufacture of plastics in primary forms	0	0	0	0.0	0.0	0.0	0.0
Manufacture of glues and gelatines	0	0	0	0.0	0.0	0.0	0.0
Manufacture of flat glass	-95	0	-4	-1.3	0.0	-0.6	-1.2
Manufacture of glass fibres	-7	0	-1	-0.1	0.0	-0.3	-0.2
Manufacture of ceramic tiles and flags	-732	171	-1,428	-7.4	17.0	-32.3	-15.1
Manufacture of bricks, tiles and construction products, in baked clay	0	0	-11	0.0	0.0	-5.2	-0.1
Manufacture of lime	-415	0	-12	-11.9	0.0	-24.8	-12.1
Manufacture of plaster products for construction purposes	-50	0	-1	-0.8	0.0	-0.5	-0.8
Manufacture of basic iron and steel and of ferro-alloys	-20,296	159	-3,379	-12.3	0.4	-8.8	-11.6
Casting of steel	0	1	0	0.0	0.4	0.0	0.0
Manufacture of agricultural tractors	0	0	-20	0.0	0.0	-0.9	-0.2
Manufacture of motor vehicles	-169	26	0	0.0	0.1	0.0	0.0

Source(s) : Cambridge Econometrics.

of the world, leading to a further increase in production abroad. This is confirmed by the results from the Reference scenario, in which rest-of-the-world production (the required increase to meet additional EU import demand and the required increase to meet the demand that was originally met by EU exports) increases in all but two sectors:

- Manufacture of plastics in primary forms
- Manufacture of glues and gelatines

In the above two sectors, the export-price elasticities of export demand are zero, as are the competing price elasticities of import demand: demand for EU exports is invariant to the export price and demand for rest-of-the-world imports is invariant to the price of domestically-produced goods. For plastics, this certainly seems counterintuitive as the product is quite homogenous, this result might reflect the fact that export and import prices move together and therefore there is often no differential in the history; particularly if the price of oil is the key determinant in driving price movements. However, a carbon cost differential will change this moving forward. For most of the other sectors, this argument does not hold because export and import prices do vary over the history.

Because of the overall reduction in EU demand, production does not shift from the EU to the rest of the world on a like-for-like basis; the increase in production from the rest of the world is smaller than the reduction in EU production.

The changes in demand in the Reference scenario, in general modest reductions in EU demand for EU-produced goods and comparatively smaller increases in rest-of-the-world production, are common to all four scenarios and, variously, reflect the low level of extra-EU trade in the sectors distinguished in the model and the seemingly low level of substitutability between goods produced inside and outside the EU (which is also seen in the trade data; many of the EU's main sources of imported goods from the rest of the world are also the main destinations for EU-produced goods).

In translating the changes in production to CO_2 emissions, the assumption is made that the *direct* emissions intensities of production are the same in the rest of the world as they are in the EU. The *indirect* emissions intensities are, however, allowed to differ to reflect differing levels of electricity emissions intensity. We do this to illustrate the relative size of relocation of carbon emissions from the shift in production. We still maintain the shift in production as the main indicator of leakage in this study.

In all but three of the sectors identified in the sector model, production in the rest of the world is more carbon-intensive than in the EU:

- Manufacture of paper and paperboard
- Manufacture of lime
- Manufacture of plaster products for construction purposes

This is a reflection of the electricity emissions intensity of the main trading partners; the above three include, among others, Norway and Switzerland; both have very low-carbon domestic power generation.

In the Reference scenario, the reduction in EU emissions from lower production is, by sector, generally quite small; less than 0.5 $MtCO_2$ pa). Three sectors see substantially larger emissions reductions and these are same ones identified (and explained) at the beginning of this section as having the largest demand reductions:

- Manufacture of ceramic tiles and flags (-15.1%)
- Manufacture of lime (-12.1%)
- Manufacture of basic iron and steel and of ferro-alloys (iron and steel) (-11.6%)

Large increases in emissions in the rest of the world from ceramics and iron and steel are largely the result of the reduction in demand for EU exports leading to increased extra-EU production rather than an increase in EU demand for imports. Extra-EU production, in terms of emissions, is also somewhat dirtier.

Allowing for differing emissions intensities in electricity in and out of the EU, the changes in demand lead to emissions from production in the rest of the world increasing by less than 25% of the reduction in the EU, on a sector by sector basis, in all but four sectors:

- Manufacture of inorganic basic chemicals
- Manufacture of ceramic tiles and flags
- Manufacture of bricks, tiles and construction products, in baked clay (exceeds 100%)
- Manufacture of agricultural tractors (exceeds 100%)

However, of these sectors, only in ceramics can the actual quantity of emissions be considered large (ie an increase in rest-of-the-world emissions of 5.6 $MtCO_2$). The emissions leakage for Basic Iron and Steel is also reasonable in absolute terms 2.7 $MtCO_2$, albeit low compared to the emissions reduction for that sector in the EU as a result of the substantial loss in production.

In the Copenhagen Low scenario, the prices of goods produced outside of the EU increase by less than 1% in all but one sector

The Copenhagen Accord Low Offers scenario differs from the Reference scenario in the assumption on mitigation action outside of the EU: in the Reference scenario, no rest-of-world action is assumed and thus no additional cost is borne by these countries' manufacturing sectors. In the Copenhagen Accord Low Offers scenario, we assume cost increases, expressed in €/tCO_2, consistent with the EU's main trading partners' Copenhagen Pledges[84] relative to the EU. None of the assumed prices exceed the EU price of €30/tCO_2 so the direct cost increases outside of the EU cannot exceed those in the EU. However, because the emissions intensity of electricity generation can exceed the EU's, the indirect cost increase could conceivably exceed that in the EU.

In the Copenhagen Accord Low Offers scenario, the final price increases are smaller in the rest of the world than in the EU and less than 1% for all but one sector. The only exception is lime, which sees a price increase of 6.7%, an import-price increase roughly half that of the increase in the domestic/export price. The changes in domestic and export demand in this scenario compared to the Reference scenario (because of the introduction of a competing price effect) are small, reducing the size of the demand reduction in EU production by 0-0.2 pp[85]. This happens for two reasons, first the import price elasticities in the import equations are low, and second because the carbon costs faced by the main trading partners still leave a reasonable cost differential compared to the EU carbon cost (see Table 6.2).

Only export demand for iron and steel sees a larger change owing to a large cross price elasticity for export demand (1.82). However, because the own-price elasticity is also large, the change is relatively small; the reduction in demand changes from -8.8% in the Reference scenario to -8.2% in the Copenhagen Accord Low Offers (see Table 7.2).

Mitigation action in the rest of the world leads to some import-demand reductions for some sectors

The introduction of an import-price increase in this scenario leads to reductions in import demand for some sectors and reductions in the size of the increase in demand for some others. Three sectors are unaffected owing to own-price elasticities of zero:

- Manufacture of paper and paperboard
- Manufacture of bricks, tiles and construction products, in baked clay
- Manufacture of agricultural tractors

In terms of emissions, for three EU sectors, emissions in this scenario are higher than in the Reference scenario because the increase in price in imports increases domestic demand:

- Manufacture of plastics in primary forms (+0.03 MtCO_2)
- Manufacture of ceramic tiles and flags (+0.07 MtCO_2)
- Manufacture of basic iron and steel and of ferro-alloys (+0.18 MtCO_2)

Emissions from sectors in the rest of the world tend to be lower in the Copenhagen Accord Low Offers scenario than the Reference, by around 0.01 MtCO_2 for all but iron and steel, for which the difference is -0.25 MtCO_2. With the exception of iron and steel, the emissions reductions arise from lower production to meet EU import

[84] Copenhagen Accord Low Offers were used if a signatory country provided a low and high alternative.

[85] pp is percentage points, for example the difference between two growth rates (expressed in percentages) would be expressed in terms of the percentage point difference.

TABLE 7.2: DEMAND IMPACTS IN THE COPENHAGEN ACCORD LOW OFFERS SCENARIO

	€m			%			
	Domestic	Import	Export	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-457	75	0	-0.8	1.4	0.0	-0.6
Manufacture of other inorganic basic chemicals	-182	-5	-47	-0.8	-0.2	-1.9	-0.9
Manufacture of plastics in primary forms	118	-11	20	0.1	-0.1	0.1	0.1
Manufacture of glues and gelatines	0	0	1	0.0	0.0	0.1	0.0
Manufacture of flat glass	-95	-2	-3	-1.3	-0.5	-0.4	-1.2
Manufacture of glass fibres	-7	0	-1	-0.1	0.0	-0.2	-0.1
Manufacture of ceramic tiles and flags	-709	168	-1,428	-7.2	16.8	-32.3	-14.9
Manufacture of bricks, tiles and construction products, in baked clay	0	0	-11	0.0	0.0	-5.2	-0.1
Manufacture of lime	-415	0	-12	-11.9	-3.5	-24.8	-12.1
Manufacture of plaster products for construction purposes	-50	0	-1	-0.8	-0.4	-0.4	-0.7
Manufacture of basic iron and steel and of ferro-alloys	-20,296	87	-3,127	-12.3	0.2	-8.2	-11.5
Casting of steel	0	0	0	0.0	0.2	0.0	0.0
Manufacture of agricultural tractors	0	0	-20	0.0	0.0	-0.9	-0.2
Manufacture of motor vehicles	-169	-1	0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

demand, rather than a lower requirement for the rest of the world to meet its own demand.

The reduction in EU emissions from adopting the EU 30% target over the 20% target is generally small

The third scenario, the 'EU Stretch' case, builds on the Copenhagen Accord Low Offers by extending the EU target to a 30% reduction in GHG emissions. Our assumption is that the cost of carbon increases to €40/tCO_2 with the level of mitigation action in the rest of the world unchanged from the Copenhagen Accord Low Offers. The price increases in the EU Stretch scenario are thus confined to the EU production and only affect the domestic and export prices.

Given that the price elasticities implemented in the model are of the expected sign, the trend of the results in the EU Stretch scenario compared to the Copenhagen Low scenario is as we would expect: higher EU production costs lead to somewhat higher prices (owing to pass-through rates that are less than one) which lead to larger falls in domestic and export demand, and larger increases in import demand for a given set of import prices (see Table 7.3).

The reductions in EU emissions are lower in the EU Stretch scenario compared to the Copenhagen Low scenario and the Reference scenario owing to the higher carbon prices. Compared to the Copenhagen Low scenario, emissions are around 0-0.1 MtCO_2 lower in the EU Stretch scenario with the exception of the sectors for which the impact of carbon pricing identified in the Reference scenario is large: emissions from the EU ceramics and lime sectors (the most emissions-intensive sectors identified in the model[86]) is around 1 $MtCO_2$ lower and for iron and steel the difference is 5.6 $MtCO_2$.

For all but

TABLE 7.3: DEMAND IMPACTS IN THE EU STRETCH SCENARIO

	€m			%			
	Domestic	Import	Export	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-609	100	0	-1.0	1.9	0.0	-0.8
Manufacture of other inorganic basic chemicals	-243	-5	-63	-1.0	-0.2	-2.6	-1.2
Manufacture of plastics in primary forms	118	-11	20	0.1	-0.1	0.1	0.1
Manufacture of glues and gelatines	0	0	1	0.0	0.0	0.1	0.0
Manufacture of flat glass	-127	-2	-4	-1.7	-0.5	-0.6	-1.6
Manufacture of glass fibres	-9	0	-1	-0.2	0.0	-0.3	-0.2
Manufacture of ceramic tiles and flags	-953	225	-1,904	-9.6	22.4	-43.1	-20.0
Manufacture of bricks, tiles and construction products, in baked clay	0	0	-15	0.0	0.0	-6.9	-0.1
Manufacture of lime	-553	0	-16	-15.9	-3.5	-33.0	-16.1
Manufacture of plaster products for construction purposes	-67	0	-1	-1.0	-0.4	-0.5	-1.0
Manufacture of basic iron and steel and of ferro-alloys	-27,061	140	-4,253	-16.4	0.3	-11.1	-15.4
Casting of steel	0	0	0	0.0	0.3	0.0	0.0
Manufacture of agricultural tractors	0	0	-27	0.0	0.0	-1.2	-0.3
Manufacture of motor vehicles	-225	7	0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

[86] Ceramics is identified by The Commission as having a carbon cost of between 5% and 30%, to ensure that the maximum risk is captured we have used the upper bound of 30%

The 'Copenhagen High' scenario sees relatively little change in mitigation cost over the EU Stretch scenario

In the 'Copenhagen High' scenario, the EU adopts its 30% target and the rest of the world undertakes actions to achieve emissions-reduction targets at the top end of the range of targets set out in the Copenhagen pledges: ie the associated costs of carbon are higher in the Copenhagen High scenario than in the Copenhagen Low or EU Stretch scenarios. In practice, around one-quarter of the trading partners distinguished in the model have higher carbon prices, an increase of €10/tCO_2 in all cases (see Table 6.2 for the complete list of carbon prices in each scenario).

Once weighted, most sectors in the rest of the world see price increases of less than 0.5 pp over those that arise from our assumptions about the price increases from the Copenhagen pledges low offers to the high offer. Notably, the price of rest-of-the-world manufacture of ceramic tiles and flags increases by 1 pp and that of lime by 3.6 pp. These are two sectors (of the 14 in the model) that were identified as facing high carbon costs 5-30% and 65.2% respectively. However, once these price increases are applied to calculate the change in demand (see Table 7.4), and once the changes in demand have been converted into implied emissions, the changes in emissions between the EU Stretch and Copenhagen High scenarios are small. The most notable are:

- Manufacture of ceramic tiles and flags: EU emissions are 0.08 MtCO_2 higher under Global Stretch compared to EU Stretch (-9.71 MtCO_2 below the 'baseline' level compared to -9.79 MtCO_2); rest-of-the-world emissions are 0.01 MtCO_2 lower (7.48 MtCO_2 above the baseline level compared to 7.49 MtCO_2)

TABLE 7.4: DEMAND IMPACTS IN THE COPENHAGEN HIGH SCENARIO

	€m			%			
	Domestic	Import	Export	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-609	100	0	-1.0	1.9	0.0	-0.8
Manufacture of other inorganic basic chemicals	-243	-7	-63	-1.0	-0.3	-2.6	-1.2
Manufacture of plastics in primary forms	141	-13	24	0.2	-0.1	0.1	0.1
Manufacture of glues and gelatines	0	0	1	0.0	0.0	0.1	0.0
Manufacture of flat glass	-127	-3	-4	-1.7	-0.6	-0.6	-1.6
Manufacture of glass fibres	-9	0	-1	-0.2	0.0	-0.2	-0.2
Manufacture of ceramic tiles and flags	-927	222	-1,904	-9.4	22.1	-43.1	-19.8
Manufacture of bricks, tiles and construction products, in baked clay	0	0	-15	0.0	0.0	-6.9	-0.1
Manufacture of lime	-553	-1	-16	-15.9	-5.4	-33.0	-16.1
Manufacture of plaster products for construction purposes	-67	0	-1	-1.0	-0.6	-0.5	-1.0
Manufacture of basic iron and steel and of ferro-alloys	-27,061	83	-4,056	-16.4	0.2	-10.6	-15.3
Casting of steel	0	0	0	0.0	0.0	0.0	0.0
Manufacture of agricultural tractors	0	0	-27	0.0	0.0	-1.2	-0.3
Manufacture of motor vehicles	-225	0	0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

- Manufacture of basic iron and steel and of ferro-alloys: EU emissions are 0.14 $MtCO_2$ higher under Copenhagen High compared to EU Stretch (-22.07 $MtCO_2$ below the baseline level compared to -22.21 $MtCO_2$); rest-of-the-world emissions are 0.19 $MtCO_2$ lower (3.15 $MtCO_2$ above the baseline level compared to 3.34 $MtCO_2$)

7.3 The Impact of Free Allocation of Allowances

At DECC's request we modelled the impact of the free allocation of EU ETS allowances to evaluate its effect at reducing carbon leakage in the test sectors. The initial European Commission Impact Assessment assumes EU ETS auctioning of 75% (ie 25% free allowances) and adjusts the initial cost impact to do this. We have followed the same methodology and adjusted the direct cost impact to reflect the proposed proportion of free allowances:

- 80% free allowances (to represent coverage of 80% of a sector's emissions which is an estimate of a typical level of allowances relative to a benchmark level)
- 50% free allowances

The two sensitivities (80% and 50% free allowances) have been modelled against the EU Stretch Copenhagen Low scenario.

The stylised assumption is that the free allocation of allowances (a transfer which affects fixed costs) is passed on in full to consumers through a reduction in variable costs. The assumption is clearly contestable, and so the results give an upper bound to the effectiveness of the policy. However, it is worth considering that if a sector truly was at risk from carbon leakage and/or substantial demand losses, it might well act to reduce cost pass-through as we have assumed.

The model results show that for most sectors this substantially reduces the impact on domestic demand and export demand. Tables 7.5 and 7.6 show, respectively, the impacts of free allowances on the components of demand at the 50% and 80% levels. The full series of impacts, combining each of the four scenarios with each of the four sensitivities, are provided in tables in Appendix K.

TABLE 7.5: DEMAND IMPACTS OF 50% FREE ALLOCATION (%)

	S3 – EU Stretch, Copenhagen Low				S3a – 50% free allocation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-0.8	1.4	0.0	-0.6
Manufacture of other inorganic basic chemicals	-1.0	-0.2	-2.6	-1.2	-0.8	-0.2	-2.0	-0.9
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.1	-0.1	0.1	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.7	-0.5	-0.6	-1.6	-1.1	-0.5	-0.3	-1.0
Manufacture of glass fibres	-0.2	0.0	-0.3	-0.2	-0.2	0.0	-0.2	-0.2
Manufacture of ceramic tiles and flags	-9.6	22.4	-43.1	-20.0	-4.9	11.6	-22.6	-10.4
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-4.1	-0.1
Manufacture of lime	-15.9	-3.5	-33.0	-16.1	-8.3	-3.5	-17.2	-8.4
Manufacture of plaster products for construction purposes	-1.0	-0.4	-0.5	-1.0	-0.6	-0.4	-0.3	-0.6
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.3	-11.1	-15.4	-11.1	0.2	-7.3	-10.4
Casting of steel	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-0.6	-0.1
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

For most sectors the impact on domestic demand (and production) is the most notable, which is not strictly carbon leakage, as there is often no corresponding shift to import supply (as discussed in Section 7.2). However, the impact on export volumes can be assumed to be carbon leakage, under the assumption that foreign producers fill the gap left by the shift away from EU producers. This is an assumption, which applies an upward bias on the findings, but the international data are not sufficient to estimate a robust relationship in the export market.

For a number of sectors, where the cross-price elasticity was found to be significant between domestic prices and import volumes, then switching from domestic production to imports is diminished as a result of free allocation and in these cases carbon leakage is therefore substantially reduced.

The distribution of free allowances only impacts on demand through the reduction of direct costs and not indirect costs, as a result, sectors which have a large direct-to-

TABLE 7.6: DEMAND IMPACTS OF 80% FREE ALLOCATION (%)

	S3 – EU Stretch, Copenhagen Low				S3b – 80% free allocation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-0.7	1.2	0.0	-0.5
Manufacture of other inorganic basic chemicals	-1.0	-0.2	-2.6	-1.2	-0.7	-0.2	-1.8	-0.8
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.1	-0.1	0.1	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.7	-0.5	-0.6	-1.6	-0.8	-0.5	-0.2	-0.8
Manufacture of glass fibres	-0.2	0.0	-0.3	-0.2	-0.2	0.0	-0.2	-0.2
Manufacture of ceramic tiles and flags	-9.6	22.4	-43.1	-20.0	-3.2	7.6	-14.9	-6.8
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-3.0	-0.1
Manufacture of lime	-15.9	-3.5	-33.0	-16.1	-5.4	-3.5	-11.3	-5.5
Manufacture of plaster products for construction purposes	-1.0	-0.4	-0.5	-1.0	-0.5	-0.4	-0.2	-0.5
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.3	-11.1	-15.4	-9.1	0.1	-5.9	-8.5
Casting of steel	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-0.4	-0.1
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

indirect cost ratio (such as ceramics and lime) are affected most by the allocation of free allowances.

Free allowances are an effective policy tool for reducing carbon leakage with respect to reducing the impact of carbon mitigation costs on exports and export demand. However, for the sectors where a relationship between domestic prices and import volumes has often not been found, there is no impact of free allowances on EU demand for imports. Free allowances will, however, have an impact on domestic demand for products where the carbon cost means that domestic demand is substantially reduced and not met by a switch to imports, the most notable example is Manufacturing of Lime. By contrast, Manufacture of Basic Metals and Steel and of Ferro Alloys, a sector which sees a large demand reduction (both domestic and export) in Scenario 2, is only partly protected by the use of free allocations, because it faces a significant indirect cost and because of the level of trade and product homogeneity there is a substantial demand reaction to price changes.

The shift to 50% allocation, from 80% allocation, reduces the effectiveness of the policy depending on the proportion of direct cost impacts to indirect cost impacts (Manufacture of Flat Glass, Manufacture of Lime, Manufacture of Agricultural Tractors and Manufacture of Ceramic Tiles and Flags[87])

7.4 The Impact of Border Adjustment Mechanisms

Another policy alternative to free allocations is the use of Border Adjustment Mechanisms (BAMs) to apply an effective carbon price differential to imports (or exports) to maintain international competitiveness. As discussed in Section 6.3 we have modelled the implementation of BAMs on import prices. This sensitivity has been modelled against the EU Stretch Copenhagen Low scenario.

Table 7.7 shows the impact of BAMs on the demand for domestic production and demand for imports for Scenario 2 (BAMs, as specified here, do not affect the demand for exports). The effect of BAMs is to reduce the impact on demand for domestic production; where there are significant cross price elasticities between import prices and domestic demand. The more widely noticed effect however, is the effectiveness of BAMs in reducing the penetration of imports for sectors where the import price elasticity for imports is significant.

For the sectors we tested, those most affected by BAMs were the sectors that saw the largest increases in import price after equalisation ie the ones where the import price was a *lot* lower than the domestic price. This occurs because the main trading partners of these sectors (flat glass, ceramics, lime, and steel) are countries with no, or low, carbon prices in the EU Stretch Copenhagen Low Scenario and so the weighted average price increase is small without BAMs. It is notable that BAMs seem to lead largely to EU import demand reduction rather than switching back to domestic production (with the exception of Manufacturing of Ceramic Tiles and Flags). BAMs are ineffective in reducing leakage through the impact of carbon mitigation costs on export demand and, as this is the main carbon leakage impact arising from loss in export demand, free allowances prove to be more effective in limiting leakage (given our modelling approach). However, BAMs, as we have modelled, have the advantage of allowing for both direct and indirect cost impacts. It is noted though, BAMs which account for indirect costs might prove difficult to implement due to complexities around the carbon intensity of electricity and would also require amendments to The Commission's Directive.

[87] As discussed in Section 7.2 Manufacture of Agricultural Tractors and Manufacture of Ceramic Tiles and Flags are assumed to have a direct cost at the upper bound of the 5%-30% range given in the EC's Impact Assessment.

TABLE 7.7: DEMAND IMPACTS OF BAMS (%)

	S3 – EU Stretch, Copenhagen Low				S3c – with BAMs			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-1.0	1.9	0.0	-0.8
Manufacture of other inorganic basic chemicals	-1.0	-0.2	-2.6	-1.2	-1.0	-0.9	-2.6	-1.2
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.3	-0.3	0.1	0.3
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.7	-0.5	-0.6	-1.6	-1.7	-1.9	-0.6	-1.6
Manufacture of glass fibres	-0.2	0.0	-0.3	-0.2	-0.2	0.0	-0.3	-0.2
Manufacture of ceramic tiles and flags	-9.6	22.4	-43.1	-20.0	-7.4	19.6	-43.1	-18.4
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-6.9	-0.1
Manufacture of lime	-15.9	-3.5	-33.0	-16.1	-15.9	-9.7	-33.0	-16.1
Manufacture of plaster products for construction purposes	-1.0	-0.4	-0.5	-1.0	-1.0	-1.1	-0.5	-1.0
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.3	-11.1	-15.4	-16.4	-0.8	-11.1	-15.4
Casting of steel	0.0	0.3	0.0	0.0	0.0	-1.0	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-1.2	-0.3
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

7.5 The Impact of Electricity Price Regulation

DECC asked the project team to consider the impact of electricity price regulation in non-EU regions, suggesting that the additional cost of carbon mitigation in the power sector might not be passed on in full to industrial consumers, and therefore international competitors would be at an even greater advantage. The project team found little substantive evidence to use pass-through rates which allowed for regulation in the various trading partners. As discussed in Section 6.3 we modelled electricity price regulation outside of the EU by assuming full price pass through in all regions (outside the EU and the EU) and testing the extreme position that electricity cost pass-through in non-EU regions is zero. The impact of this sensitivity is displayed in Table 7.8.

The results show very little impact from lowering the electricity cost pass-through to zero in extra-EU regions. The greatest impact is seen in sectors where the indirect-to-direct cost ratio is greatest. The conclusion reached for the 14 sectors analysed, therefore, is that the direct cost is a much more important factor, and moreover, the EU import own price elasticities suggest that the price impact can be absorbed fairly easily.

TABLE 7.8: DEMAND IMPACTS OF NO OVERSEAS ELECTRICITY COST PASS-THROUGH (%)

	S3 – EU Stretch, Copenhagen Low				S3d – no cost pass-through			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-1.0	1.9	0.0	-0.8
Manufacture of other inorganic basic chemicals	-1.0	-0.2	-2.6	-1.2	-1.0	-0.1	-2.6	-1.2
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.1	0.0	0.0	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Manufacture of flat glass	-1.7	-0.5	-0.6	-1.6	-1.7	-0.3	-0.7	-1.6
Manufacture of glass fibres	-0.2	0.0	-0.3	-0.2	-0.2	0.0	-0.3	-0.2
Manufacture of ceramic tiles and flags	-9.6	22.4	-43.1	-20.0	-9.7	22.5	-43.1	-20.0
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-6.9	-0.1
Manufacture of lime	-15.9	-3.5	-33.0	-16.1	-15.9	-3.5	-33.0	-16.1
Manufacture of plaster products for construction purposes	-1.0	-0.4	-0.5	-1.0	-1.0	-0.4	-0.6	-1.0
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.3	-11.1	-15.4	-16.4	0.4	-11.3	-15.4
Casting of steel	0.0	0.3	0.0	0.0	0.0	0.5	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-1.2	-0.3
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0

Source(s) : Cambridge Econometrics.

8 Concluding Remarks

Overall, the research findings are mixed, and reflect the heterogeneity of the sectors selected for assessment. This chapter summarises the key themes of the project, from both phases of the work and highlights some differences between the extent to which sectors are at risk of carbon leakage from:

- the qualitative analysis and industry consultation
- the quantitative assessments

The contrast between the two sets of analyses suggests an avenue for further research.

Key findings

Of the 14 sectors assessed quantitatively, we only find strong evidence of production losses (the indicator we have used to represent carbon leakage) in three sectors:

- Manufacturing of Lime
- Manufacturing of Basic Iron and Steel and Ferro-Alloys
- Manufacturing of Ceramic Tiles and Flags.

For a further four sectors, our results show very modest production losses:

- Manufacture of Paper and Paperboard
- Manufacture of Other Inorganic Basic Chemicals
- Manufacture of Flat Glass
- Manufacture of Plaster Products for Construction Purposes

For the remaining seven sectors the impact of carbon cost differentials are found to be negligible.

In broad terms, the qualitative and quantitative research agree on which sectors are relatively more at risk of carbon leakage

For the most part, the qualitative analysis is consistent with and supports the findings of the quantitative assessment. However, the quantitative analysis is able to give consideration to three important factors outside the scope of the model frameworks:

- the impact of supply chain cost increases
- the co-location of industrial processes
- additional regulatory cost pressures

The result is that the qualitative assessments often suggest that more sectors are potentially at risk of carbon leakage than those identified by the quantitative assessment.

The impact of a shift from the EU 20% goal to a 30% goal is modest

Interestingly, the shift from the EU 20% GHG reduction target to an EU 30% GHG reduction target does little to worsen the production loss, except for the sectors already heavily affected. Further, our analysis suggests that the use of free allowances as a policy tool to reduce leakage would be sufficient to offset a substantial proportion of the additional production losses. Our analysis also suggests that free allowances are more effective than Border Adjustment Mechanisms because of the impact free allowances have on reducing the domestic and export demand impacts.

The Commission's criteria seem robust but are possibly too inclusive

The Commission's criteria for identifying sectors at risk of carbon leakage seem fairly robust. The three sectors we find to be at most risk have also been identified by The Commission to be at risk. We also find that sectors identified by The Commission as not being at risk of carbon leakage face no, or negligible, production losses in our quantitative assessment. However, The Commission's criteria might cast the net too wide, as we find only modest evidence of leakage for some sectors identified by The Commission to be at risk. It remains difficult to apply additional criteria to identify the sectors most at risk. In Phase 1, we were unable to identify robust criteria which could be applied across all sectors. Moreover, there is an additional problem with the application of multiple criteria in that it requires some form of (often subjective) weighting when forming a composite indicator.

Modelling caveats

However, our results are based on a number of caveats which further future research should seek to develop. The sector framework developed for the analysis, by design and because of data limitations, does not account for the potential increasing costs of other materials as a result of carbon cost increases in those supplying sectors (with the exception of the electricity sector). Also, the model, due to its comparative static framework, is unable to account for dynamics (there is no indication as to the time span or path of the impacts) or the impacts on the wider economy and potential feedbacks. The modelling is therefore both partial and static as the disaggregated detail of the sectors necessitates. The sector framework also separates the assessment of carbon costs for the production of intermediates and their traded derivatives, which, though integrated on the same site are classified to different sectors.

The pass-through rates used are based on broader sector definitions

We have used pass-through rates from CE’s E3ME model of Europe. This means that the pass-through rate assumptions currently included in the tool used to carry out the sector analyses are estimated on historical data. The assumption is that cost increases seen by the sectors are passed on in the same way that other cost increases have been passed on in the past. Moreover, these rates are estimated for sectors at a higher level of aggregation than the sectors identified in the sector framework tool; the E3ME sectors generally correspond to NACE two-digit sectors, whereas the sectors assess in this study are NACE three or four-digit sectors. The model has been implemented in such a way that alternative pass-through rate assumptions are easily changed.

It is important to emphasise that we have adopted a partial and static modelling approach; we are only concerned with the demand loss as a result of the expected price changes. However, we recognise that if costs are not passed on through prices then they must be absorbed through reduced profits. This may have implications for long term investment and competitiveness of the sectors which is not captured in our analytical framework.

Pass-through rates determine the type of competitiveness loss

It is difficult to make any firm conclusion regarding the impact of pass-through rates on leakage. If a firm passes costs on this might be because it can, but it might be because it simply cannot absorb the cost. In either case it will face a demand reaction. If a firm chooses not to pass costs on and instead absorbs them in the form of lower profits, this might reduce long-term inward investment in productive capacity in regions with high carbon prices.

Further avenues for research

Our main recommendation is that sectors which might be at risk of carbon leakage on the basis of our additional criteria, or at the top end of The Commission’s criteria are subject to further assessment. In particular, we recommend a focus on sectors where either the carbon abatement potential is limited, or the sector is important in the value added chain. There are also qualitative factors which need to be considered to obtain a better understanding of leakage and will require consultation with industry: an example is the co-location of one industrial process with another.

Deeper analysis is required for sectors identified at risk, with a focus on industry structure and market segmentation

Particularly, we recommend a focus on industry structure and market segmentation as these criteria were most quoted in the literature, the implication being that these controlled the degree to which sectors could pass their costs through, and hence mitigate any impacts. Both national and international market structures were seen as important. But despite its recognised importance, industry structure was not easily comparable across sectors. Quantitative measures are available for some sectors mainly resulting from analysis of issues of competition, but there are gaps for sectors without such concerns and this type of analysis is often specific to certain time periods. As methodological approaches already exist, it may be possible to develop a standardised methodology focusing on the interaction between leakage and industry structure for particular sectors in future studies.

To supplement the above, we also recommend that 'whole-economy' modelling studies are undertaken to understand the dynamics and inter-industry relationships across the economy, which have been identified as important after consultation with industry stakeholders, while also assessing second order effects such as the impact on employment and incomes feeding back to product demand.

The data are currently insufficient in a number of key areas including the coverage of Member States, the coverage of key factors and the robustness of the available data

We also strongly recommend that both Member State and EU statistical agencies improve the quality and richness of the data required to make assessments of carbon leakage. In some cases key economic data are found to be severely lacking: feedback from industry suggests that they fundamentally disagree with some of the sector specific data employed in this study, upon which some key policy conclusions are reached. Moreover, data are simply missing for a number of key indicators required to assess the risk of carbon leakage with greater levels of confidence. We found data to be missing in our alternative criteria suggestions and in the data required for the econometric analysis. The only solution to this informative critique is to improve the data sets available, in consultation with industry, policy-makers and academia, and hence provide a more robust evidence base for policy formulation

This study represents just one approach to looking at carbon leakage and the results are known to be conditioned by the level of sectoral disaggregation. We believe that any subsequent quantitative research approach should now be focused on sectors generally agreed to be at risk of carbon leakage, both to understand the complex interactions (eg vertical integration and co-location) between sectors rather than looking at sectors in isolation, and to understand the dynamic responses of firms with reduced profit margins in sectors which cannot pass on costs. Perhaps most importantly, robust data sources to support additional criteria identified as important need to be developed. We also recommend more detailed dynamic, whole-economy modelling to better understand the wider economic implications. The research should be undertaken in consultation with industry to ensure that the findings obtained are robust and plausible.

Appendix A: Manufacture of Flat Glass

Sector description

The Manufacture of Flat Glass is an economic activity classified at the NACE four-digit level. It covers the manufacture of flat glass, including wired, coloured or tinted flat glass. It has the four-digit code 2611 in NACE Rev 1.1[88] and 2311 in NACE Rev 2[89].

Data coverage

The most notable gaps in the data at the NACE four-digit level are in the domestic output price index and producer price index series, for which only 10-20% of the series are actual data. By contrast the output and labour data are substantially more complete and the extra-EU export and import series are without gaps. There is little improvement in the availability of the price data at the three-digit level and a substantial improvement at the two-digit level (see Table A.1).

Data analysis

Table A.1 highlights the paucity of price data available for this sector at the NACE four-digit level (amounting to a mere five countries out of 27). The implication is that data from a more aggregated classification may be necessary to produce a large enough dataset for the purposes of estimation. Thus, where data at the four-digit level of detail are available, they are used; where such data are missing, data at the two-digit level are used instead.

TABLE A.1: DATA AVAILABILITY FOR THE MANUFACTURE OF FLAT GLASS

	% of data points missing (1995-2007 * 27 EU Member States)		
	NACE four-digit	NACE three-digit	NACE two-digit
Domestic output price index	81.5	70.4	22.2
Producer price index	88.9	77.8	25.9
Production value	19.4	3.7	0.0
Wages and salaries	23.1	3.7	0.0
Number of persons employed	15.7	3.7	0.0
Extra-EU exports	0.0	0.0	0.0
Extra-EU imports	0.0	0.0	0.0

Source(s): Eurostat.

88 http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_NOM_DTL_VIEW&StrNom=NACE_1_1&StrLanguageCode=EN&IntPcKey=586631&IntKey=586687&StrLayoutCode=HIERARCHIC&IntCurrentPage=1

89 http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_NOM_DTL_VIEW&StrNom=NACE_REV2&StrLanguageCode=EN&IntPcKey=18500864&IntKey=18500894&StrLayoutCode=HIERARCHIC&IntCurrentPage=1

Five countries were excluded from the estimation sample owing to a lack of output data (the production value series) at the NACE four-digit level: the Czech Republic, Denmark, Luxembourg, Slovenia and Sweden. In the absence of any data at this level of detail, the data-filling approach described in Chapter 4 of this report cannot be applied.

A further three countries (Estonia, Latvia and Malta) were excluded from the sample because of zero output (which is distinct from the missing data described in the previous paragraph), implying no domestic Flat Glass sector.

Slovakia was excluded from the sample because the domestic price data are missing at all levels of NACE detail.

Cyprus was also dropped from the estimation sample. For this country, output was zero until 2001 with later values being either zero, small, or missing. The filling procedure was found to perform poorly on a number of series relating to this country and sector and the resulting series were not considered suitable for inclusion in the final sample.

Data on the producer price index were not available at any level of NACE detail for Portugal. This data series was used as an instrument in the estimation of the domestic demand equation and Portugal was thus excluded from the estimation of this particular equation. The sample for the estimation of the domestic demand equation also excludes Bulgaria, Ireland and Lithuania. Once the dependent variable was formed (domestic production minus exports), the series for these three countries contained some negative values. These countries were consequently dropped from the sample.

In total, ten countries were excluded from the estimation sample: 37% (130) of the potential observations. A further four (Bulgaria, Ireland, Lithuania and Portugal) were excluded from the domestic demand equation owing to the absence of data for one of the instruments used or because the dependent variable series contained negative values.

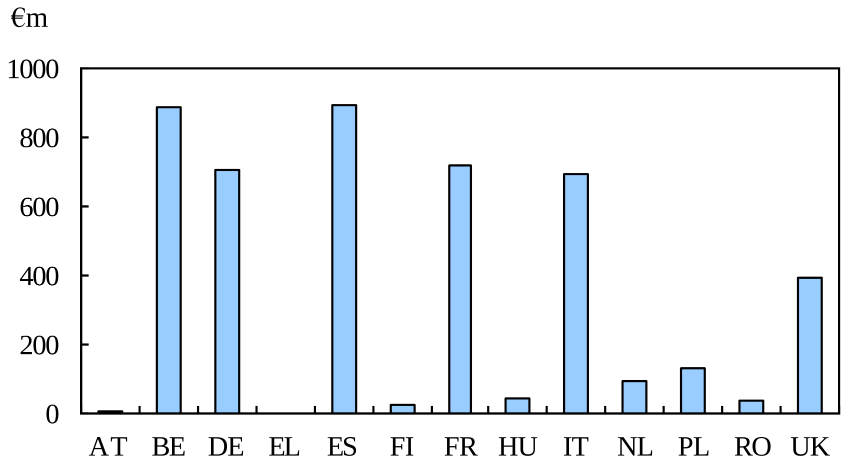
Chart A.1 shows a clear distinction between large and small demanders of Flat Glass.

Belgium, Germany, Spain, France, Italy and the UK can be considered large demanders, the others small.

Chart A.2 shows Germany, Greece, Spain, Italy and the UK to be the largest importers of Flat Glass in the EU. The rest are relatively small with Belgium, France and the Netherlands somewhat larger.

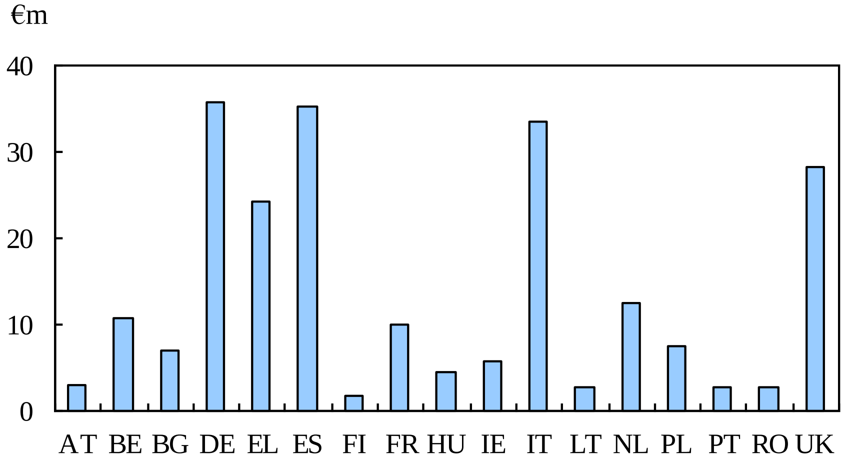
Chart A.3 shows Belgium and Germany to be, by far, the largest exporters of Flat Glass to the rest of the world. France and the UK are appreciably smaller than the aforementioned countries as extra-EU exporters and the rest of the EU Member States are small when measured in terms of their exports outside of the EU.

CHART A.1: MEAN OF DOMESTIC DEMAND



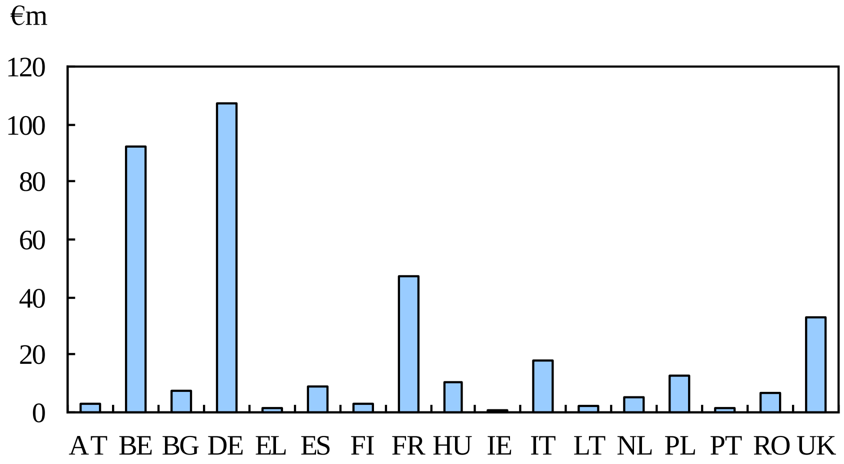
Note(s) : Figures are the means of domestic production less exports for each country over 1995-2007.
Source(s) : Eurostat.

CHART A.2: MEAN OF EXTRA-EU IMPORT VALUE



Note(s) : Figures are the means of extra-EU imports for each country over 1995-2007.
Source(s) : Eurostat.

CHART A.3: MEAN OF EXTRA-EU EXPORT VALUE



Note(s) : Figures are the means of domestic production for each country over 1995-2007.
Source(s) : Eurostat.

Table A.2 contains various descriptive statistics for the domestic price data series for the countries used in the estimation of the domestic demand equation and suggests that there is sufficient variation in the series, both within and between countries, for it to be suitable for estimation.

The relationship between the domestic price and the instruments can be seen in Table A.3.

TABLE A.2: VARIATION IN DOMESTIC PRICES (2005=100)

	Mean	Median	Maximum	Minimum	Standard deviation	# observations
AT	88.75	87.26	107.66	73.37	10.82	13
BE	92.66	93.49	108.42	80.23	9.19	13
DE	113.97	105.63	152.97	99.98	14.89	13
EL	87.13	87.84	110.05	65.23	13.98	13
ES	99.97	99.79	129.96	90.81	10.09	13
FI	95.69	96.02	109.45	86.94	6.46	13
FR	112.05	110.54	123.43	106.54	4.77	13
HU	81.00	85.34	107.73	53.48	19.54	13
IT	99.35	98.78	114.06	90.38	6.32	13
NL	98.46	99.66	109.41	92.78	5.07	13
PL	92.04	99.34	113.66	63.48	14.28	13
RO	60.16	47.94	111.73	28.66	32.05	13
UK	146.97	144.50	171.83	128.78	12.44	13

Source(s): Eurostat, Cambridge Econometrics.

TABLE A.3: RELATIONSHIP BETWEEN THE DOMESTIC PRICE AND ITS INSTRUMENTS

	Covariance	Correlation	Probability
Domestic price	558.89	1.00	-
Wages and salaries	458.42	0.36	0.00
Producer price index	320.16	0.79	0.00
Employment	-2738.95	-0.06	0.43

Source(s): Eurostat, Cambridge Econometrics.

The analysis suggests that employment is quite a weak instrument while the others exhibit statistically significant correlation, with the relationship between the domestic price and the producer price index particularly strong. The order and rank conditions can be considered satisfied.

Table A.4 shows the relationship between the extra-EU import price and its instrument.

A moderate, and statistically significant, level of correlation was found between the extra-EU import price and its instrument. The instrument may be considered suitable for use in the estimation.

In the case of extra-EU export price, the order and rank conditions would seem to be satisfied although the strength of the correlation between the export price and the candidate instruments is weaker than the relationships observed for the domestic and extra-EU import-price variables. In the case of wages and salaries, the degree of correlation is low and, statistically, not different from zero (see Table A.5).

TABLE A.4: RELATIONSHIP BETWEEN THE EXTRA-EU IMPORT PRICE AND ITS INSTRUMENT

	Covariance	Correlation	Probability
Extra-EU import price	1782.83	1.00	-
Weighted industrial wages and salaries in non-EU countries	81016.90	0.46	0.00

Source(s): Eurostat, Cambridge Econometrics.

TABLE A.5: RELATIONSHIP BETWEEN THE EXTRA-EU EXPORT PRICE AND ITS INSTRUMENTS

	Covariance	Correlation	Probability
Extra-EU export price	3633.44	1.00	-
Wages and salaries	-64.90	-0.02	0.76
Producer price index	235.85	0.22	0.00
Employment	-20915.85	-0.19	0.00

Note(s): Statistics relating to the producer price index exclude Portugal from the sample analysed owing to an absence of data at all levels of NACE detail.
Source(s): Eurostat, Cambridge Econometrics.

TABLE A.6: ESTIMATION RESULTS FROM THE DOMESTIC DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	7.76	0.53	14.61	0.00
Domestic price index	-0.65	0.12	-5.58	0.00
R-squared	0.98			
Adjusted R-squared	0.98			
# instruments	2			

Source(s): Cambridge Econometrics.

Results

For the domestic demand equation, the results of the Hausman test rejected the null hypothesis of no endogeneity and the final equation was estimated by Two-Stage Least Squares (TSLS). Activity and import prices were not found to be statistically significant and, as a result, only two terms appear in the final equation: domestic prices and a constant (see Table A.6). Tests for joint significance of the cross-section and period fixed effects failed to reject the null hypotheses of no joint significance, supporting their inclusion in the final equation. Judged by the R-squared value, the fit of the equation appears good and the estimated value of the price elasticity, between -1 and 0 is in line with our intuition.

The final equation specification settled on for import demand was estimated by Ordinary Least Squares (OLS) owing to the use of two terms that include the extra-EU import price: a standalone term but also one in which the price has been interacted with a dummy variable to denote countries that import large amounts of Flat Glass from outside the EU (see Table A.7). Because only one instrument is available for this equation, it was not possible to estimate the equation by TSLS. Period fixed effects were found to be significant in this equation; cross-section fixed effects cannot

TABLE A.7: ESTIMATION RESULTS FROM THE IMPORT DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	15.87	0.57	27.90	0.00
Extra-EU import price	0.26	0.18	1.47	0.14
Extra-EU import price * dummy variable to indicate a large importer	-0.97	0.29	-3.37	0.00
R-squared	0.89			
Adjusted R-squared	0.88			
# instruments	0			

Source(s): Cambridge Econometrics.

TABLE A.8: ESTIMATION RESULTS FROM THE EXPORT DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	16.09	0.83	19.41	0.00
GDP deflator	-0.15	0.09	-1.73	0.09
Extra-EU import price	0.24	0.14	1.79	0.08
Extra-EU export price	-0.30	0.16	-1.85	0.07
R-squared	0.92			
Adjusted R-squared	0.91			
#instruments	0			

Source(s): Cambridge Econometrics.

be included owing to the presence of the larger-importers dummy variable.

The estimated price elasticity for importers that are not large is, counterintuitively, positive but for the five countries identified as large importers (and which, combined, account for almost half of extra-EU imports by value) the price elasticity takes a more theoretically-appealing value of -0.71 (0.26 – 0.97). Alternative dummy variables were tried but these did not improve the quality of the estimates or the equation fit.

The Hausman test on the final estimated export equation failed to reject the null hypothesis of no endogeneity and the equation was estimated by OLS as a consequence. Both cross-section and period fixed effects were included in this equation, as supported by the results of the significance tests.

All the variables in the final specification are of the expected sign and significant at the 10% level (see Table A.8). The elasticity of interest, on the extra-EU export price, has a value of -0.30. Various dummy variables were tried but did not lead to any improvement in the results.

Diagnostic tests

Unit root tests were carried out to assess the extent to which the equations suffer from problems of time-series persistence. The null hypothesis is that the residuals from the estimated equations are non-stationary; the alternative is that they are stationary. Table A.9 shows the results of the unit root test carried out on the residuals from the domestic demand equation and indicates that, for this equation and dataset, there is evidence to suggest stationarity in the residuals.

TABLE A.9: UNIT ROOT TEST ON THE RESIDUALS FROM THE DOMESTIC DEMAND EQUATION

	Statistic	Probability	# cross sections	# observations
Levin, Lin & Chu test	-2.19	0.01	13	156

Note(s): The unit root test assumes a common unit root process.
Source(s): Cambridge Econometrics.

TABLE A.10: CORRELOGRAM OF THE RESIDUALS FROM THE DOMESTIC DEMAND EQUATION

	Autocorrelation	Partial correlation	Q-Statistic	Probability
1	0.52	0.52	46.76	0.00
2	0.22	-0.07	55.08	0.00
3	0.11	0.03	57.04	0.00
4	-0.06	-0.16	57.75	0.00
5	-0.12	-0.02	60.30	0.00
6	-0.20	-0.15	67.22	0.00
7	-0.22	-0.05	75.80	0.00
8	-0.23	-0.11	85.06	0.00
9	-0.23	-0.09	94.97	0.00
10	-0.14	0.01	98.68	0.00
11	-0.09	-0.06	100.25	0.00
12	-0.05	-0.02	100.70	0.00

Source(s): Cambridge Econometrics.

Table A.10 indicates a strong degree of autocorrelation in the residuals from the domestic demand equation and thus evidence of serial correlation. This is perhaps to be expected given that panel data have been used and the equation specification contains no dynamics. There is, however, no impact on the point estimates obtained because the White Heteroskedasticity robust estimator has been used throughout the econometric analysis. The residuals from the trade equations exhibit similar properties to those from the domestic demand equation.

Conclusions

The parameter estimates obtained for this sector are, in general, in line with economic theory: in the range [-1,0]. The import equation is perhaps the weakest of the three, in terms of the goodness-of-fit as well as the presence of a counterintuitive point estimate of the price elasticity for small importers. For this equation, it would seem reasonable to select the price elasticity for large importers for use in the sector model.

Appendix B: Manufacture of Plastics in Primary Forms

Introduction

The Manufacture of Plastics in Primary Forms is an economic activity classified at the NACE four-digit level. It covers the manufacture of plastic products for use in the construction industry. It has the four-digit code 24.16 under NACE Rev 1.1[90] and 20.16 under NACE Rev 2[91]. It belongs to the Manufacture of Basic Chemicals industry (24.1 Rev 1.1 and 20.1 Rev 2) which , in turn is grouped under the broader NACE 2-digit classification of Manufacture of Chemicals and Chemical Products (24 Rev 1.1 and 20 Rev 2).

Data Coverage

Table B.1 below summarises data availability for this sector Price variables generally have the largest percentage of missing values for this sector at the NACE four-digit level, and the coverage does not improve much at NACE three- digit level. Only at NACE 2-digit level does the coverage improve considerably. Missing data are filled using the methodology described in Chapter 4.

TABLE B.1: DATA AVAILABILITY FOR THE MANUFACTURE OF PLASTICS IN PRIMARY FORMS INDUSTRY

	% of missing data points 1995-2007 * 27 EU Member States		
Variables	NACE four-digit	NACE three-digit	NACE two-digit
Domestic output price index	77.8	70.9	35.0
Producer price index	85.8	81.8	43.6
Production value	34.5	26.5	11.4
Wages and salaries	36.2	28.2	14.8
Number of persons employed	35.6	29.3	17.1
Extra-EU imports	30.8	30.8	30.8
Extra-EU exports	30.8	30.8	30.8

Source(s) : Eurostat.

[90] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:006:0003:0034:EN:PDF

[91] http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NACE_REV2&StrLanguageCode=EN&IntPcKey=&StrLayoutCode=HIERARCHIC&CFID=777843&CFTOKEN=5902e1781799e86f-6E5AAE84-9E00-3409-87B3E71F52CDFE91&jsessionid=1e517066588cded2a4db23d356e502549443TR

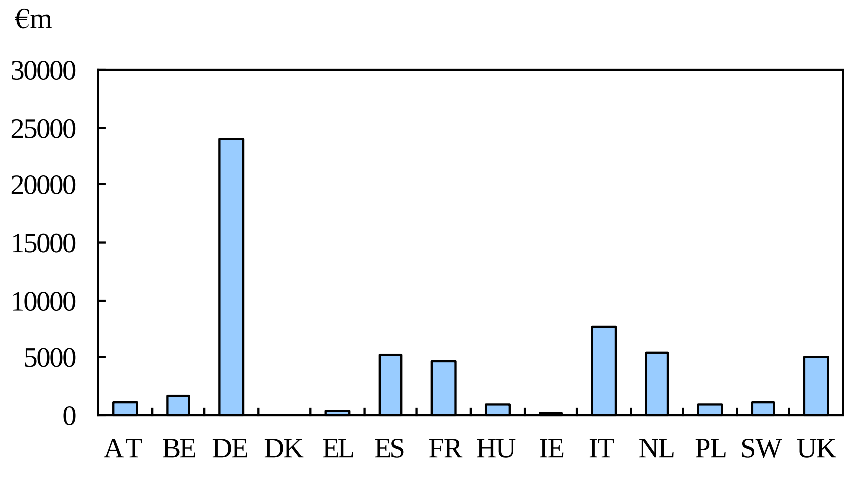
Data Analysis

Sample size

The sample size used for each of the equations differed, based on the availability and quality of the data for the variables specific to each equation. However, some of the excluded countries were common to all of the equations, due to a complete lack of data in key variables before the filling technique was carried out. These countries were as follows: Cyprus, Czech Republic, Latvia, Luxembourg and Malta. For the domestic demand equation Estonia, Finland, Slovakia and Portugal were further excluded from the estimation due to missing data, and Lithuania, Bulgaria, Romania and Slovenia were excluded due to unusual data, leaving a sample of 14 cross-sections. The export demand equation also included the same cross sections. For the import demand equation the same 13 countries were excluded, as well as several more due to unusual data. These extra countries were Austria, the UK, Poland and France, leaving a sample of ten cross sections.

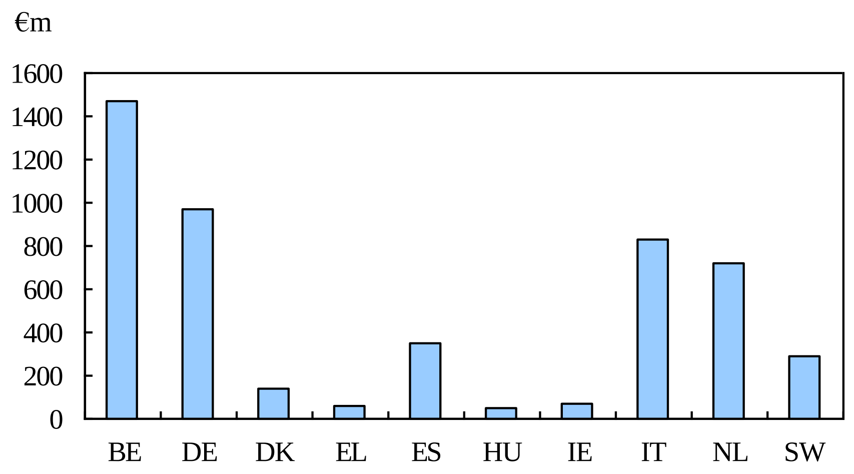
Charts B.1, B.2 and B.3 below provide details of the mean domestic production values, import values and export values by country for the sector, respectively. Major producer countries are; Germany, Spain, France, Italy, the Netherlands and the UK. The main importer countries are Belgium, Germany, Italy, the Netherlands and the UK while the main extra-EU exporter countries are Belgium, Germany, Spain, France, Italy, the Netherlands and the UK.

CHART B.1: MEAN OF DOMESTIC DEMAND



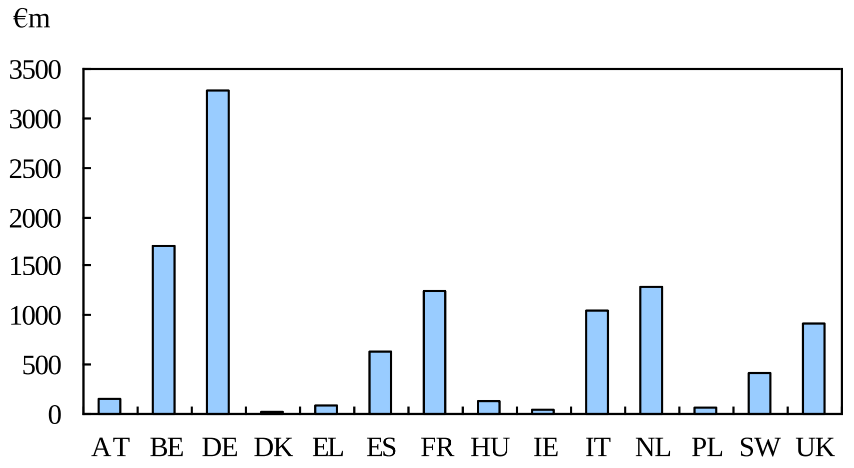
Note(s) : Figures are the means of domestic production less exports for each country over 1995-2007.
Source(s) : Eurostat.

CHART B.2: MEAN OF EXTRA-EU IMPORT VALUE



Note(s) : Figures are the means of extra-EU imports for each country over 1995-2007.
Source(s) : Eurostat.

CHART B.3: MEAN OF EXTRA-EU EXPORT VALUE



Note(s) : Figures are the means of domestic production for each country over 1995-2007.
Source(s) : Eurostat.

Table B.2 contains various descriptive statistics and shows that there is sufficient variation of the domestic price variable both between Member States and across time to allow it to be used as an explanatory variable in estimation.

TABLE B.2: VARIATION IN DOMESTIC PRICE INDEX (2005=100)

Country	Mean	Median	Maximum	Minimum	Standard deviation	Number of observations
AT	97.46	98.02	110.85	84.35	6.71	13.00
BE	90.33	89.91	109.16	78.97	10.42	13.00
BG	84.54	88.73	109.00	64.78	15.46	13.00
DE	95.70	94.72	105.16	89.42	4.71	13.00
DK	91.13	86.86	104.90	81.32	7.48	13.00
EL	93.90	94.50	104.37	84.13	6.41	13.00
ES	92.00	91.45	106.34	83.93	7.51	13.00
FR	94.01	92.84	102.51	88.45	4.76	13.00
HU	78.87	76.16	111.75	57.04	19.43	13.00
IE	89.16	92.01	102.09	78.72	8.53	13.00
IT	89.40	85.90	103.82	82.90	7.55	13.00
LT	90.21	87.92	122.29	68.85	14.69	13.00
NL	83.96	79.70	114.90	70.05	15.57	13.00
PL	102.72	98.70	145.43	87.63	16.43	13.00
PT	90.86	88.99	105.68	82.28	7.91	13.00
RO	63.58	54.88	113.87	34.68	29.21	13.00
SI	81.88	89.44	100.48	50.70	17.73	13.00
SW	90.26	92.58	109.29	71.05	10.51	13.00
UK	97.69	96.89	105.73	92.56	3.81	13.00
All	89.35	91.22	145.43	34.68	14.95	247.00

Source(s): Eurostat, Cambridge Econometrics.

The relationship between price and instruments

Tables B.3 to B.5 report the covariance and correlation between the potentially endogenous price variable in the equations and the instruments employed. This analysis allows us to assess whether the rank condition is satisfied.

There appears to be a positive, statistically significant correlation between the domestic price and all of its instruments. The instruments may therefore be considered suitable for use in estimation. It can also be shown from the table that both the order and rank conditions are satisfied.

There appears to be, as Table B.4 shows, a positive, statistically significant correlation between the extra-EU import price and its instrument, weighted industrial wages and salaries in non-EU countries. Both the order and rank conditions are satisfied.

There appears to be a positive statistically significant correlation between the extra-EU export price and two of its instruments, namely wages and salaries and the producer price index, as Table B.5 demonstrates. The relationship between the extra-EU export price and the number of persons employed is less clear. There seems to be some correlation between the price variable and the selected instrument, and this may be sufficient to satisfy the rank condition.

TABLE B.3: RELATIONSHIP BETWEEN THE DOMESTIC PRICE AND ITS INSTRUMENTS

	Covariance	Correlation	Probability
Domestic price	233.52	1.00	-
Wages and salaries	2337.16	0.15	0.02
Producer price index	184.35	0.79	0.00
Employment	46220.50	0.415	0.02

Source(s): Eurostat, Cambridge Econometrics.

TABLE B.4: RELATIONSHIP BETWEEN THE EXTRA-EU IMPORT PRICE AND ITS INSTRUMENT

	Covariance	Correlation	Probability
Extra-EU import price	4407.86	1.00	-
Weighted industrial wages and salaries in non-EU countries	315070.40	0.56	0.00

Source(s): Eurostat, Cambridge Econometrics.

TABLE B.5: RELATIONSHIP BETWEEN THE EXTRA-EU EXPORT PRICE AND ITS INSTRUMENTS

	Covariance	Correlation	Probability
Extra-EU export price	4893.75	1.00	-
Wages and salaries	7678.85	0.11	0.10
Producer price index	277.78	0.26	0.00
Employment	117324.70	0.08	0.21

Source(s): Eurostat, Cambridge Econometrics.

Results

The Hausman test was conducted to assess whether there was evidence of endogeneity with respect to the price variable (see Chapter 4 for more details regarding this test). The null hypothesis of this test is that there is no endogeneity (i.e. there is no correlation between the variable and the error term).

In the case of the domestic demand equation the Hausman test rejected the null-hypothesis of no endogeneity, suggesting that the domestic price variable was endogenous. The instruments used in this equation were oil prices and producer prices in the industry.

In the case of the import demand equation, the Hausman test fails to reject the null-hypothesis of no endogeneity (p-value of 0.32) so no instruments were used for this equation.

Similarly, in the case of the import demand equation, the Hausman test also fails to reject the null-hypothesis of no endogeneity (p-value of 0.33) so no instruments were used for this equation.

The results reject the null-hypothesis that the cross section fixed effects are jointly insignificant for the domestic demand equation. It is therefore justified to use cross section fixed effects for this equation. However, the null hypothesis, that the period fixed effects are jointly insignificant, could not be rejected. Therefore period fixed effects were not used for the domestic demand equation. For the trade equations both cross section and period fixed effects were required.

The domestic demand equation

TABLE B.6: ESTIMATION RESULTS FOR THE DOMESTIC DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	6.17	2.91	2.12	0.04
Output of main demanders	1.22	0.31	3.86	0.00
Domestic price	-0.41	0.44	-0.92	0.36
Extra-EU import prices	0.53	0.26	2.03	0.04
R-squared	0.93			
Adjusted R-squared	0.92			
Instruments	2			

Source(s): Cambridge Econometrics.

For the domestic demand equation the dependent variable used was domestic output minus exports, as explained in Chapter 4, in order to just pick up domestic demand for domestic production, instead of production for both domestic and external demand. It was found that the results from the equation using this as the dependent variable were better than when output alone was used. It was also found that including an instrumental variable for oil prices improved the results considerably. Oil is a primary input to the manufacture of plastic, therefore it would be expected that prices of plastic products will move in line with oil prices.

Despite these improvements, the results from the estimation of the domestic demand equation, shown in Table B.6, does not provide a statistically significant domestic price elasticity of demand. However, the variables representing import prices and the output of the main customer industries have the correct coefficient signs and are statistically significant.

The import demand equation

TABLE B.7: ESTIMATION RESULTS FOR THE IMPORT DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	13.20	2.83	4.67	0.00
GDP	0.65	0.22	3.02	0.00
Extra-EU import price	-0.41	0.16	-2.52	0.01
R-squared	0.99			
Adjusted R-squared	0.99			
Instruments	0			

Source(s): Cambridge Econometrics.

The results from the estimation of the import demand equation do yield a statistically significant relationship between the import price and demand. Both the explanatory variables used have the correct coefficient signs and are both statistically significant. The R-squared coefficient is also very high, suggesting the equation explains nearly all of the variation in the dependent variable.

The export demand equation

TABLE B.8: ESTIMATION RESULTS FOR THE EXPORT DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	17.61	1.00	17.69	0.00
Extra-EU import prices	0.42	0.20	2.12	0.04
Extra-EU export prices	-0.02	0.11	-0.17	0.86
R-squared	0.98			
Adjusted R-squared	0.98			
Instruments	0			

Source(s): Cambridge Econometrics.

The results for the export demand equation are shown in Table B.8. The coefficient signs for the explanatory variables are theoretically correct in this equation, and are of a sensible magnitude. While the variable for import prices is statistically significant at the 5% level, the variable for export prices is not. The R-squared coefficient is very high, suggesting the equation fits the data well. The world activity variable was not found to improve the fit of the equation and was statistically insignificant in explaining the demand for exports.

Diagnostic Tests

The unit root test is a test for stationarity in the residuals from an estimated equation and is used to assess whether or not the equation suffers from problems with time series persistence. The null hypothesis is non-stationarity and the alternative hypothesis is stationarity. The results for the domestic demand equation are given in the Table B.9; similar tests were performed for the trade equations. In the case of the domestic demand equation the null-hypothesis of non-stationarity can be rejected at the 5% level, suggesting time series persistence is not a problem. However, the null-hypothesis could not be rejected in the case of the trade equations, suggesting they suffer from time series persistence.

TABLE B.9: UNIT ROOT TEST ON THE RESIDUALS FROM THE DOMESTIC DEMAND EQUATION

Method	Statistic	Probability*	Cross-sections	Observations
Levin, Lin & Chu test	-1.98	0.02	14	168

Note(s): The unit root test assumes a common unit root process.
Source(s): Cambridge Econometrics.

Correlogram of the residuals

There is a strong autocorrelation in the residuals for the domestic demand equation as Table B.10, which presents the correlogram of the residuals, indicates. Similar results are found in the trade equations.

TABLE B.10: CORRELOGRAM OF THE RESIDUALS

	AC	PAC	Q-Stat	Probability
1	0.607	0.607	68.19	0.000
2	0.394	0.040	97.01	0.000
3	0.199	-0.087	104.40	0.000
4	0.008	-0.146	104.41	0.000
5	-0.136	-0.118	107.93	0.000
6	-0.217	-0.068	116.86	0.000
7	-0.245	-0.043	128.36	0.000
8	-0.298	-0.139	145.44	0.000
9	-0.318	-0.117	165.05	0.000
10	-0.228	0.045	175.19	0.000
11	-0.192	-0.074	182.44	0.000
12	-0.072	0.064	183.47	0.000

Source(s): Cambridge Econometrics.

This suggests that there is serial correlation in the residuals which is to be expected owing to the omission of dynamics from the equation. However, it has no impact on the robustness of the results owing to the use of the White Heteroskedasticity robust estimator.

Conclusions

We can conclude that the results for all the equations were reasonable, and can tell us something about demand in the sector. In all three equations the coefficient signs of all the explanatory variables were correct and in line with economic theory. The R-squared coefficients were also high in all three equations, especially the trade equations. Both the trade equations also seem to suffer from time series persistence.

A final point to note is that, owing to the general nature of the methodology, it was not possible to include industry-specific factors in these equations. It is important to note, however, that many industry-specific factors will have been captured by the cross-section or period specific effects (or indeed by the intercept). However, those industry-specific factors which vary both between Member States and over time will have been excluded.

Appendix C: Casting of Steel

Introduction

The Casting of Steel 2752[92] is an economic activity classified at the NACE four-digit level. The sector belongs to the Casting of Metals industry which, in turn belongs to the broader NACE two-digit industry of Manufacture of Basic Metals.

Data Coverage

Table C.1 summarises the data availability for a number of key variables relevant to the analysis at the NACE 2, 3 and 4-digit levels. Macro variables such as GDP are not reported in the table as they are general to all industries and have a full set of data.

Domestic output and producer prices have by far the most missing data at all NACE levels. Coverage at the 3 and 4-digit levels is so poor that extensive filling with 2-digit data is unavoidable. However, even the 2-digit data are incomplete, so we shall be forced to omit some countries from the estimation.

Import volumes and prices are complete at the 4-digit level, and require no filling. The remaining variables have decent but not complete coverage at the 4-digit level. In these cases, filling with 3 and 2-digit data is possible, using the methodology described in Chapter 4, but it will usually be preferable to omit countries from the estimation instead.

TABLE C.1: DATA AVAILABILITY FOR MANUFACTURE OF CASTING OF STEEL

	% missing data points out of a possible 351 (27 EU member states across 1995-2007)		
Variable	NACE 4	NACE 3	NACE 2
Employment	12%	3%	4%
Domestic Output Price	85%	81%	22%
Producer Price	93%	81%	30%
Wages & Salaries	10%	3%	4%
Domestic Production	10%	3%	4%
Import Volumes	0%	0%	0%
Export Volumes	5%	0%	0%
Extra-EU Import Prices	0%	0%	0%
Extra-EU Export Prices	4%	0%	0%

Source(s) : Eurostat, Cambridge Econometrics.

[92] http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_NOM_DTL_VIEW&StrNom=NACE_1_1&StrLanguageCode=EN&IntPcKey=589487&IntKey=589599&StrLayoutCode=HIERARCHIC&IntCurrentPage=1

Data Analysis

Sample Sizes

The data for each variable and country were examined for missing values and for strange and possibly spurious series. The data for a number of countries was dropped, generally due to missing (or zero) values.

Cyprus, Estonia, Latvia, Luxembourg, Malta and Slovakia were dropped from the domestic and import demand estimations, since the equations require domestic output prices and this variable was unavailable for these countries even at the NACE 2-digit level. This leaves a sample size in both cases of 351 – (13x6) = 273. There were no data for Lithuania for wages & salaries, domestic output and employment at the four-digit level, however, this could be filled using NACE 3-digit data in order to preserve the sample size. These variables are not required for the import equations, and so the inclusion of Lithuania was not an issue.

In addition, producer price indices (PPI) is a possible instrument for the domestic equations, but there are no data for this variable at any level for Ireland or Portugal, on top of the countries also missing domestic price data. Therefore, when PPI is used as an instrument, the domestic sample size comes down further to 247.

In addition, in the case of the import equation, data for weighted wages & salaries are not available in the year 2007. This cuts the sample size down to 252.

The export equations do not require domestic output price data. However, they use wages & salaries and employment as instruments, and therefore Cyprus, Estonia, Latvia, Luxembourg, Malta and Slovakia[93] are excluded, since these countries either have zero wages & salaries and/or employment at the 4-digit level, or partially missing data such that filling with 3-digit data produces poor results. It was considered that these countries were sufficiently small and few in number that the benefits of more reliable data outweighed the costs reduced degrees of freedom. With these countries excluded, the sample size is 351 – (13x6) = 273. As above, Lithuania is missing at the 4-digit level, and requires filling with 3-digit data if it is to be included.

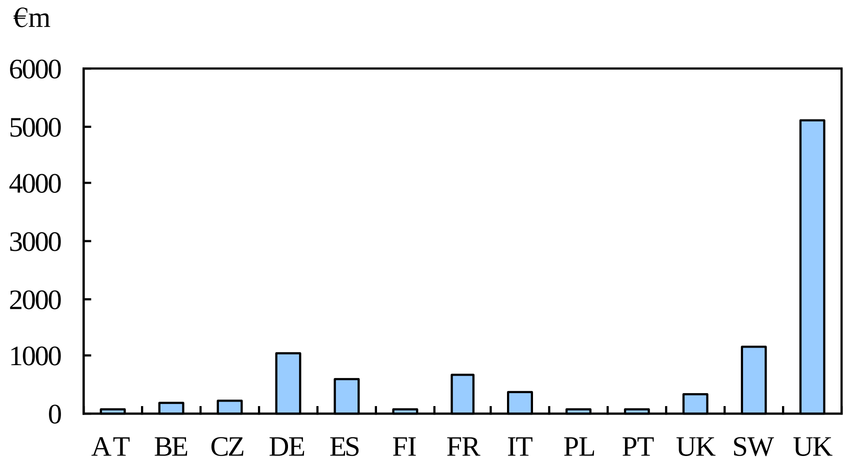
As with the domestic equation, PPI is again a possible instrument for the exports data, but data for Portugal and Ireland are missing, in addition to the six countries above. Therefore, using PPI as an instrument brings the sample size down to 234.

[93] Co-incidentally, the same countries as are excluded from the domestic equation

Mean production/import & export volumes

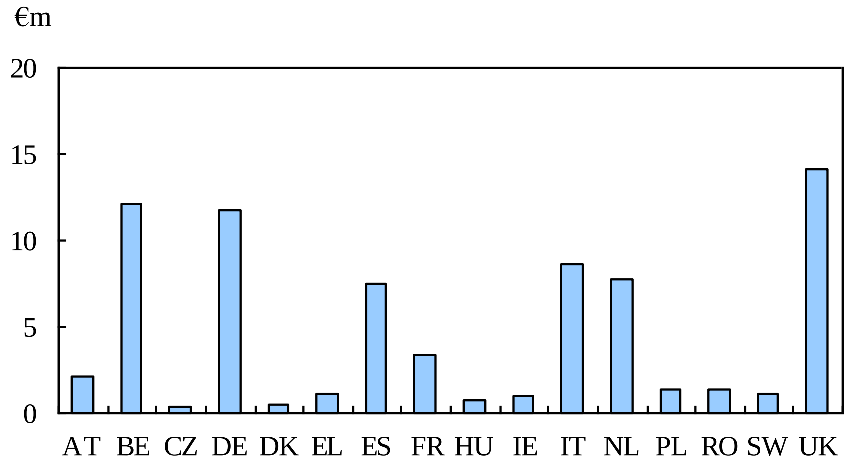
The three charts below show the mean levels over 1995-2007 of domestic demand, extra-EU import values and extra-EU export values in the Casting of Steel sector for each country[94].

CHART C.1: MEAN OF VALUE OF DOMESTIC DEMAND



Note(s) : Figures are the means of domestic production less exports for each country over 1995-2007.
Source(s) : Eurostat.

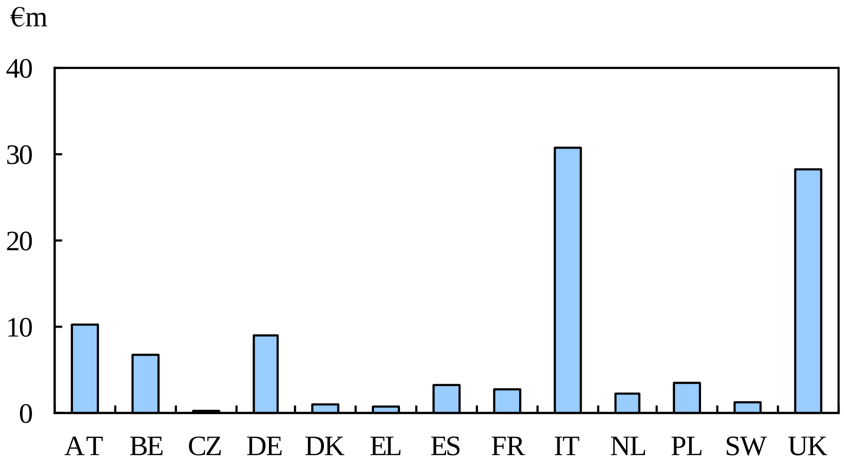
CHART C.2: MEAN OF EXTRA-EU IMPORT VALUE



Note(s) : Figures are the means of extra-EU imports for each country over 1995-2007.
Source(s) : Eurostat.

[94] These charts show the 4-digit data once filled with 3-digit and 2-digit data

CHART C.3: MEAN OF EXTRA-EU EXPORT VALUE



Note(s) : Figures are the means of extra-EU exports for each country over 1995-2007.
Source(s) : Eurostat.

The UK is the largest consumer of domestic steel by far in the EU. Therefore, a UK dummy will be considered for inclusion in the domestic equation.

The UK is the largest importer of cast steel in the EU, closely followed by Belgium and Germany. Therefore, a UK/Belgium/Germany dummy will be considered for inclusion in the import equation. Spain, Italy and the Netherlands are also major importers.

The largest exporters of cast steel in the EU are Italy and the UK by some distance. Therefore, an Italy/UK dummy will be considered for inclusion in the export equation.

A further message to take from all three charts is that the countries being excluded from the estimation (see above) are all very minor players in the sector, in absolute terms, with the partial exception of Slovakia, and would therefore not materially affect the results.

Variation in prices

The following table suggests that there is sufficient variation in domestic output prices, both between Member States across time, for it to be suitable for estimation. Import and export prices were also sufficiently varied.

TABLE C.2: VARIATION IN DOMESTIC PRICES

Country	Mean	Median	Max	Min.	Std. Dev.	Obs.
AT	92.56638	90.64000	106.9800	82.50000	6.868973	13
BE	86.75077	76.06000	142.2900	67.16000	24.29450	13
BG	80.24830	72.27000	133.6500	56.85650	24.68662	13
CZ	80.50154	74.55000	106.3200	67.15000	13.72273	13
DE	91.63769	88.91000	111.6300	81.00000	9.057483	13
DK	86.30145	86.61550	117.2600	68.58000	15.55517	13
EL	88.72385	85.86000	115.7000	74.59000	12.67995	13
ES	86.16692	78.99000	125.7100	70.17000	17.83975	13
FI	86.70538	78.46000	130.7600	68.62000	18.94933	13
FR	98.10000	95.64000	114.1100	93.08000	5.900870	13
HU	76.08677	69.66000	117.9800	51.89310	22.09205	13
IE	99.68462	95.22000	155.0100	84.40000	18.59310	13
IT	84.83077	77.59000	126.0100	69.71000	16.62808	13
LT	100.4383	101.4100	120.4600	81.14040	11.33792	13
NL	86.74923	81.87000	116.0700	74.87000	12.87498	13
PL	90.47132	88.50420	121.4000	71.10000	16.62744	13
PT	98.79601	96.36000	120.8627	91.05000	9.095968	13
RO	66.98367	56.30000	123.0400	35.46680	31.81300	13
SI	80.10645	80.66000	119.4600	59.74000	19.35273	13
SW	79.13462	67.31000	138.4200	59.41000	24.68733	13
UK	87.53809	85.23920	101.4447	82.66000	5.389207	13
All	87.07248	86.51000	155.0100	35.46680	18.70644	273

Source(s) : Eurostat, Cambridge Econometrics.

Relationship between price and the preferred instruments

The following tables show the covariance between domestic output prices, import prices and export prices and the various proposed instruments. They need to be significantly correlated in order for the assumptions behind instrument variable estimation to be valid.

There is statistically significant correlation between PPI and Employment and the domestic price, so these can be considered suitable instruments. There is almost no

TABLE C.3: RELATIONSHIP BETWEEN DOMESTIC PRICE AND ITS INSTRUMENTS

Instrument	Covariance	Correlation	Probability
Employment	5.98E+11	0.839311	0.0000
Producer Price Index	7.93E+08	0.152201	0.0167
Wages & Salaries	2.04E+10	0.946768	0.0000

Source(s) : Eurostat, Cambridge Econometrics.

confidence in the correlation between Wages & Salaries and domestic price. This suggests that it would be better to limit the instruments to PPI and Employment. Even so, there is a case for excluding PPI due to concerns about the lack of data at the NACE 4-digit level All instruments are collinear with one another.

TABLE C.4: RELATIONSHIP BETWEEN IMPORT PRICE AND ITS INSTRUMENT

Instrument	Covariance	Correlation	Probability
Extra-EU Weighted Wages & Salaries	-102978.7	-0.126178	0.0454

Source(s) : Eurostat, Cambridge Econometrics.

The correlation between the instrument and import prices is statistically significant at the 5% confidence level – enough to justify continuing with the estimation and using weighted wages & salaries as an instrument.

TABLE C.5: RELATIONSHIP BETWEEN EXPORT PRICE AND ITS INSTRUMENTS

Instrument	Covariance	Correlation	Probability
Employment	-78497.84	-0.103236	0.1055
Producer Price Index	-212.4344	-0.038172	0.5504
Wages & Salaries	1502.787	0.065459	0.3055

Source(s) : Eurostat, Cambridge Econometrics.

These are poor results. Employment is the instrument we can have most confidence in (there is a 10.5% chance that employment and export price are not correlated). However, there is little confidence in the correlation between PPI or wages & salaries and the export price, so these cannot be considered suitable instruments for use in estimation.

Functional Form Tests

Hausman test for endogeneity

A series of Hausman tests were conducted to assess whether there was evidence of endogeneity. The null hypothesis is that there is no endogeneity whereas the alternative hypothesis is that there is endogeneity. If endogeneity is present, instrument variable techniques are used in the final estimation. The results were as follows:

- *Domestic Demand:* some versions of the domestic demand equation reject the null hypothesis that there is no endogeneity with a high level of confidence. However, for the final version of the equation, which included PPI and drops fixed effects between countries (see below) the Hausman test p-value[95] is 95%, and so the hypothesis that there is no endogeneity cannot be rejected.
- *Import Demand:* the null hypothesis that there is no endogeneity is not always rejected, mainly failing to be so when heterogeneity dummies are included in the equation. However, the final version of the equation (see below) rejects the hypothesis with a confidence greater than 3%.

[95] ie the probability that the null hypothesis is true

- *Export Demand:* the Hausman test fails to rejects the null hypothesis that there is no endogeneity in all cases, even at a low-powered 10% confidence level. Therefore, instrument variable techniques are probably not suitable. Given the results in Table C.5, the Hausman test may have failed to reject the hypothesis because our instruments are poor, rather than because there is actually no endogeneity.

Fixed Effect Tests Fixed effect techniques are used to control for unobserved variation across countries and time periods, but this comes at the cost of reducing the degrees of freedom. However, hypothesis tests that the impacts of the fixed effects techniques were insignificant were rejected in all cases, which justify their inclusion.

Results

Domestic Demand The Hausman tests indicate that there is no endogeneity, and so instrument variables are not used. Wages & Salaries is not considered suitable as an instrument. In addition, we would rather avoid using PPI as an instrument, since it includes a lot of filled data, and reduces the sample sizes. However, the results without PPI were poor, probably due to misspecification, and so it is nonetheless included in the final equation. In addition, the income and deflator variables had coefficients that did not conform to *a priori* economic theory expectations, and so these variables were eliminated[96].

The final domestic equation is shown in Table C.6:

The estimate of price elasticity is theoretically plausible, at -0.42% and in line with our intuition. However, the statistical properties of this estimate are not very good.

TABLE C.6: ESTIMATION RESULTS FROM THE DOMESTIC DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		19.39167	1.237864	15.66542	0.0000
Extra-EU Import Price		0.055800	0.058758	0.949663	0.3434
Domestic Price		**-0.423057**	0.278172	-1.520847	0.1299
R-squared	0.971036				
Adjusted R-squared	0.966591				
Instruments	PPI				

Source(s) : Eurostat, Cambridge Econometrics.

Its standard error is large enough that the estimate is only different from zero with a confidence level of 13%. However, R^2 is high. Further variations on the equation were tested, but this did not improve the results (and hence are not reported here).

96 It was judged that Casting of Steel is a sufficiently small sector to allow the elimination of the GDP deflator variable while retaining PPI as an instrument

Import Demand

The Hausman tests, in most cases, indicate that there is endogeneity, and so instrument variables should be used. Initial results, using heterogeneity dummies, had poor statistical and theoretical properties. Removing the dummies, replacing GDP with QINT, and removing intra-EU import prices improved the equation. Finally, the income variables (QINT and/or GDP) were removed altogether, as the coefficients on them were positive and counter-intuitive and also against theoretical expectations:

The results shown in Table C.7 match our theoretical expectations reasonably well and also appear statistically sound. The variables are significant and R^2 is high, while the coefficients on the price variables have the expected sign.

Export demand

TABLE C.7: ESTIMATION RESULTS FROM THE IMPORT DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		21.399	4.872	4.392	0.000
Domestic Price		0.675	0.311	2.171	0.031
Import Price		-1.893	0.929	-2.561	0.043
R-squared	0.865				
Adjusted R-squared	0.844				
Instruments	WW&S				

Source(s) : Eurostat, Cambridge Econometrics.

Pre-estimation checks indicated that endogeneity was not present. Even if instrument variable estimation were attempted, no instruments were sufficiently correlated with export prices. Therefore, OLS estimation with fixed effects was attempted instead.

The export price elasticity, as shown in Table C.8 is negative and in line with theoretical expectations. However, the standard errors of the coefficients on import and export prices are high, and as a result both of these coefficients are insignificantly different from zero at the 10% level of confidence. However, this was the best

TABLE C.8: ESTIMATION RESULTS FOR THE EXPORT DEMAND EQUATION FOR THE CASTING OF STEEL

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		14.772	1.015	15.54692	0.0000
Extra-EU Export Price		-0.178	0.118	-1.452647	0.1410
R-squared	0.920				
Adjusted R-squared	0.909				
Instruments	N/A				

Source(s) : Eurostat, Cambridge Econometrics.

specification of the equation that could be obtained with the available data and which gave a good fit as indicated by the high R^2.

Diagnostic Tests

The hypothesis that there is a unit root in the residuals of the domestic demand equations cannot be rejected by an Augmented Dicky Fuller (ADF test) as Table C.9 shows However, there is clearly correlation between the residuals, as shown by the correlogram (see Table C.10) and a plot of the residuals. This is to be expected, given the lack of dynamics in the equations.

This is also the case for the export demand equation. However, the hypothesis that there is a unit root in the residuals of the import equation is rejected. Even so, the correlogram and residual plot clearly show that there is time series persistence in the equation.

TABLE C.9: UNIT ROOT TEST

Method	Statistic	Probability*	Cross-sections	Observations
Augmented Dicky-Fuller	49.0236	0.1551	20	240

Note(s): * Probabilities for Fisher tests are computed using an asymptotic Chi –square distribution. All other tests assume asymptotic normality.
Source(s) : Eurostat, Cambridge Econometrics.

TABLE C.10: CORRELOGRAM OF THE RESIDUALS

	AC	PAC	Q-Stat	Probability
1	0.871	0.871	199.41	0.000
2	0.762	0.016	352.74	0.000
3	0.660	-0.027	468.34	0.000
4	0.581	0.033	558.01	0.000
5	0.509	-0.002	627.33	0.000
6	0.447	-0.002	680.92	0.000
7	0.379	-0.052	719.65	0.000
8	0.317	-0.020	746.82	0.000
9	0.257	-0.029	764.75	0.000
10	0.203	-0.021	775.98	0.000
11	0.140	-0.078	781.33	0.000
12	0.068	-0.094	782.58	0.000

Source(s) : Eurostat, Cambridge Econometrics.

Conclusions

The parameter estimates obtained for this sector were mixed. Generally, the coefficient signs were as expected on a priori economic theory grounds, and in line with our intuition and hence, usable in the sector model. However, there are some problems with the domestic and export equations that limit our confidence in their findings. In particular, the estimates of price elasticity have large standard errors, and were not significantly different from zero with a high level of confidence.

TABLE C.11: SUMMARY OF PRICE ELASTICITIES

		Domestic Equation		**Import Equation**		**Export Equation**	
NACE code	**Sector**	**Domestic Price**	**Import Price**	**Import Price**	**Domestic Price**	**Export Price**	**Import Price**
2752	Casting of Steel	-0.42	0.056	-1.43	N/A	-0.18	N/A

Source(s) : Eurostat, Cambridge Econometrics.

Appendix D: Manufacture of Glass Fibres

Sector description

The Manufacture of Glass Fibres is an economic activity classified at the NACE four-digit level. It covers the manufacture of glass fibres, including glass wool and non-woven products thereof. It excludes the manufacture of woven fabrics of glass yarn as well as the manufacture of fibre optic cable for data transmission or live transmission of images. It has the four-digit code 2614 in NACE Rev 1.1[97] and 2314 in NACE Rev 2[98].

Data coverage

The most notable gaps in the data at the NACE four-digit level are in the domestic output price index and producer price index series, for which only 10-20% of the series are actual data. By contrast the output and labour data are substantially more complete and the extra-EU export and import series are without gaps. There is little improvement in the availability of the price data at the three-digit level and a substantial improvement at the two-digit level (see Table D.1).

Data analysis

Table D.1 highlights the paucity of price data available for this sector at the NACE four-digit level (amounting to a mere four countries out of 27). The implication is that data from a more aggregated classification may be necessary to produce a large enough dataset for the purposes of estimation. Thus, where data at the four-digit level

TABLE D.1: DATA AVAILABILITY FOR THE MANUFACTURE OF GLASS FIBRES

	% of data points missing (1995-2007 * 27 EU Member States)		
	NACE four-digit	NACE three-digit	NACE two-digit
Domestic output price index	85.2	70.4	22.2
Producer price index	88.9	77.8	25.9
Production value	15.4	3.7	0.0
Wages and salaries	15.7	3.7	0.0
Number of persons employed	16.0	3.7	0.0
Extra-EU exports	0.0	0.0	0.0
Extra-EU imports	0.0	0.0	0.0

Source(s): Eurostat.

97 http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_NOM_DTL_VIEW&StrNom=NACE_1_1&StrLanguageCode=EN&IntPcKey=586631&IntKey=586855&StrLayoutCode=HIERARCHIC&IntCurrentPage=1

98 http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_NOM_DTL_VIEW&StrNom=NACE_REV2&StrLanguageCode=EN&IntPcKey=18500864&IntKey=18500984&StrLayoutCode=HIERARCHIC&IntCurrentPage=1

of detail are available, they are used; where such data are missing, data at the two-digit level are used instead.

Four countries were excluded from the estimation sample owing to series composed entirely of missing data: the Czech Republic, Greece, Ireland and Slovenia. In these cases, the data filling method described in Chapter 4 is inappropriate.

A further four countries (Estonia, Latvia, Lithuania and Luxembourg) were excluded because of zero output (which is distinct from the missing data described in the previous paragraph), implying no domestic Glass Fibres sector.

Another three countries (Cyprus, Malta and Slovakia) were excluded owing to a lack of domestic price data at all levels of NACE detail.

Poland was excluded from the domestic demand equation because the dependent variable used in this equation is domestic production minus exports; the resulting series for Poland contained some negative values, indicating that some export demand is not met by domestic production, but from imports; Poland could be considered to act as an intermediary for international trade. Data on the producer price index were not available at any level of NACE detail for Portugal. This data series was used as an instrument in the estimation of the domestic demand equation and Portugal was thus excluded from the estimation of this particular equation.

Four further countries were excluded from the estimation sample for the export demand equation because they are small extra-EU exporters: Bulgaria, Hungary, Portugal and Romania. The mean of these countries' exports by value over the sample period was less than €1m and for some the price data series contained some odd trends that suggest poor data. Excluding these countries led to an overall improvement in the estimation results for this equation.

In total, for the import demand equation, eleven countries were excluded from the estimation sample: 41% (143) of the potential observations. Two more countries (Poland and Portugal) were excluded from the sample used to estimate the domestic demand equation owing to negative values in the transformed series and missing data for the selected instrument, respectively. Four additional countries (Bulgaria, Hungary, Portugal and Romania) were excluded from the estimation of the export demand equation owing to substantially smaller extra-EU exports than the other countries in the sample.

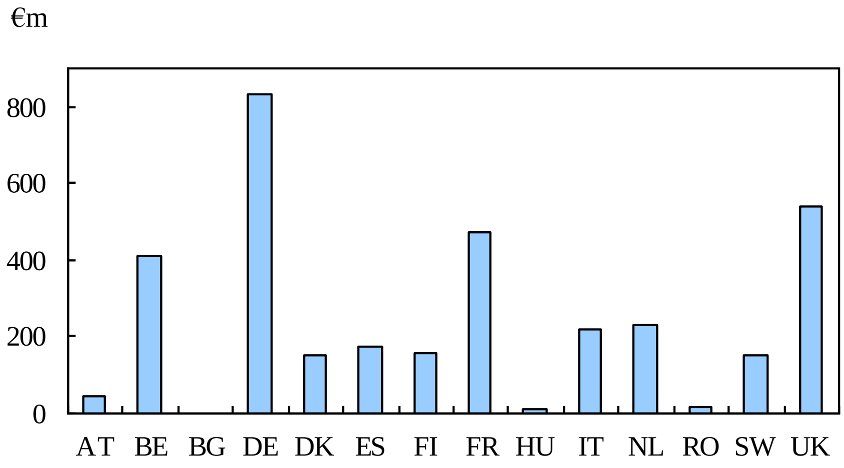
Chart D.1 shows a clear distinction between large and small demanders of Glass Fibres. Germany can be seen to have, by far, the largest demand for Glass Fibres by value, followed by Belgium, France and the UK.

In terms of extra-EU imports, by value, Germany, France and the UK are the largest importers with Belgium, Denmark, Spain, Italy, the Netherlands and Sweden somewhat large (see Chart D.2).

Chart D.3 shows Germany to be the largest extra-EU exporter of Glass Fibres, followed by Italy and the UK.

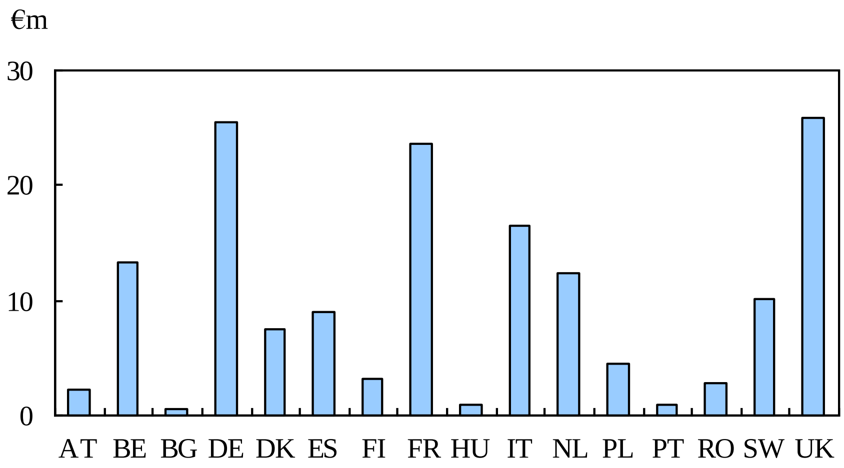
Table D.2 contains various descriptive statistics for the domestic price data series for the countries used in the estimation of the domestic demand equation and suggests that there is sufficient variation in the series, both within and between countries, for it to be suitable for estimation.

CHART D.1: MEAN OF DOMESTIC DEMAND



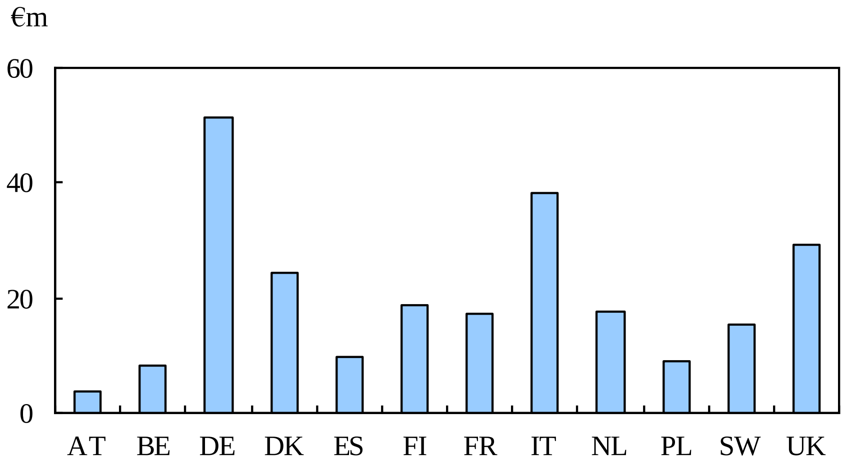
Note(s) : Figures are the means of domestic production less exports for each country over 1995-2007.
Source(s) : Eurostat.

CHART D.2: MEAN OF EXTRA-EU IMPORT VALUE



Note(s) : Figures are the means of extra-EU imports for each country over 1995-2007.
Source(s) : Eurostat.

CHART D.3: MEAN OF EXTRA-EU EXPORT VALUE



Note(s) : Figures are the means of domestic production for each country over 1995-2007.
Source(s) : Eurostat.

TABLE D.2: VARIATION IN DOMESTIC PRICES (2005=100)

	Mean	Median	Maximum	Minimum	Standard deviation	# observations
AT	88.75	87.26	107.66	73.37	10.82	13
BE	92.66	93.49	108.42	80.23	9.19	13
BG	87.81	88.89	114.49	72.72	13.42	13
DE	103.02	102.58	108.66	100.01	3.05	13
DK	89.68	86.74	114.51	78.13	10.65	13
ES	93.08	92.18	111.43	82.35	8.67	13
FI	95.69	96.02	109.45	86.94	6.46	13
FR	107.48	106.57	115.46	103.78	3.08	13
HU	81.00	85.34	107.73	53.48	19.54	13
IT	102.95	102.01	110.35	95.99	4.60	13
NL	98.46	99.66	109.41	92.78	5.07	13
RO	60.16	47.94	111.73	28.66	32.05	13
SW	91.98	92.31	107.85	77.31	8.91	13
UK	130.75	128.56	152.87	114.57	11.07	13

Source(s): Eurostat, Cambridge Econometrics.

TABLE D.3: RELATIONSHIP BETWEEN THE DOMESTIC PRICE AND ITS INSTRUMENTS

	Covariance	Correlation	Probability
Domestic price	373.63	1.00	-
Wages and salaries	494.51	0.52	0.00
Producer price index	259.12	0.84	0.00
Employment	11139.51	0.40	0.00

Source(s): Eurostat, Cambridge Econometrics.

The relationship between the domestic price and the instruments can be seen in Table D.3. The table suggests statistically-significant relationships between the domestic price and all the available instruments. The relationship between the domestic price and the producer price index is particularly strong. The order and rank conditions can be considered satisfied.

Table D.4 shows the relationship between the extra-EU import price and its instrument. The degree of correlation between the extra-EU import price and its instrument is weak and of moderate statistical significance. The order and rank conditions would appear to be loosely satisfied.

The relationships between the extra-EU export price and its instruments appear quite weak (see Table D.5). In the case of the producer price index, the relationship does not appear to be statistically significant. Based on the available instruments, the order and rank conditions appear to be satisfied but the instruments would seem to be of relatively poor quality.

TABLE D.4: RELATIONSHIP BETWEEN THE EXTRA-EU IMPORT PRICE AND ITS INSTRUMENT

	Covariance	Correlation	Probability
Extra-EU import price	23562.33	1.00	-
Weighted industrial wages and salaries in non-EU countries	-53538.87	-0.12	0.08

Source(s): Eurostat, Cambridge Econometrics.

TABLE D.5: RELATIONSHIP BETWEEN THE EXTRA-EU EXPORT PRICE AND ITS INSTRUMENTS

	Covariance	Correlation	Probability
Extra-EU export price	50245.51	1.00	-
Wages and salaries	2458.13	0.23	0.00
Producer price index	168.94	0.09	0.27
Employment	62556.54	0.19	0.02

Source(s): Eurostat, Cambridge Econometrics.

TABLE D.6: ESTIMATION RESULTS FROM THE DOMESTIC DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	0.36	2.55	0.14	0.89
GDP	0.40	0.22	1.86	0.07
Domestic price index	-0.19	0.10	-1.90	0.06
R-squared	0.99			
Adjusted R-squared	0.98			
# instruments	3			

Source(s): Cambridge Econometrics.

Results

For the domestic demand equation, the results of the Hausman test rejected the null hypothesis of no endogeneity; the final equation was estimated by Two-Stage Least Squares (TSLS). The price of extra-EU imports and the GDP deflator were not found to be statistically significant and were thus excluded from the final equation specification. Statistically significant elasticities were found for GDP and the domestic price index (see Table D.6). The signs of the estimated coefficients are as we would expect and are of sensible magnitudes. The point estimate of the domestic price elasticity is -0.19. The fit of the equation, based on the R-squared value, is good.

Joint significance tests on the fixed effects failed to reject the null hypothesis that the period fixed effects are insignificant; the cross-section fixed effects were retained.

The final equation specification settled on for import demand was estimated by Ordinary Least Squares (OLS) owing to the use of two terms that include the extra-EU import price: a standalone term but also one in which the price has been interacted with a dummy variable to denote countries that import large quantities of Glass Fibres from outside the EU (see Table D.7). Because only one instrument is available for this equation, it was not possible to estimate the equation by TSLS. The domestic price was not found to be significant and was thus excluded from the final specification. Period fixed effects were found to be significant in this equation; cross-section fixed effects cannot be included owing to the presence of the larger-importers dummy variable.

The estimated price elasticity for extra-EU importers that are not considered large is of the expected sign and has a value of -0.26. The price elasticity for large importers is -0.01 (-0.26 + 0.25). This result is statistically significant although is perhaps not significant in economic terms, given how close it is to zero, indicating an inelastic price elasticity of demand. The implication is that extra-EU imports of Glass Fibres are driven more by activity than by price. Interestingly, a number of alternative specifications (that were eventually rejected in favour of the specification reported here) suggested that the coefficient on the extra-EU import price was not statistically different from zero.

TABLE D.7: ESTIMATION RESULTS FROM THE IMPORT DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	9.60	0.56	17.23	0.00
Output from main demanders	0.55	0.04	14.04	0.00
Extra-EU import price	-0.26	0.09	-2.72	0.01
Extra-EU import price * dummy variable to indicate a large importer	0.25	0.02	11.69	0.00
R-squared	0.83			
Adjusted R-squared	0.82			
# instruments	0			

Source(s): Cambridge Econometrics.

The fit of the equation, as judged by its R-squared, is reasonable, at 0.83. Alternative specifications with alternative dummy variables were tried but led to no improvement in the equation results.

The Hausman test on the final estimated export equation failed to reject the null hypothesis of no endogeneity; the equation was estimated by OLS. Both cross-section and period fixed effects were included in this equation, as supported by the results of the significance tests.

All the variables in the final specification are of the expected sign and significant (see Table D.8). The elasticity of interest, on the extra-EU export price, has a value of -0.38 while the extra-EU import price elasticity (a proxy for the domestic price of Glass Fibres in non-EU countries) is estimated to be 0.27. The implication is that countries outside of the EU are quicker to reduce their demand for EU Glass Fibres in response to an EU price increase than they are to reduce their demand for domestically-produced Glass Fibres in response to a similar percentage increase. Various dummy variables were tried but did not lead to any improvement in the results.

TABLE D.8: ESTIMATION RESULTS FROM THE EXPORT DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	17.17	0.95	18.13	0.00
Extra-EU import price	0.27	0.11	2.49	0.01
Extra-EU export price	-0.38	0.13	-2.86	0.00
R-squared	0.83			
Adjusted R-squared	0.79			
#instruments	0			

Source(s): Cambridge Econometrics.

TABLE D.9: UNIT ROOT TEST ON THE RESIDUALS FROM THE DOMESTIC DEMAND EQUATION

	Statistic	Probability	# cross sections	# observations
Levin, Lin & Chu test	-1.55	0.06	14	168

Note(s): The unit root test assumes a common unit root process.
Source(s): Cambridge Econometrics.

Diagnostic tests

Unit root tests were carried out to assess the extent to which the equations suffer from problems of time-series persistence. The null hypothesis is that the residuals from the estimated equations are non-stationary; the alternative is that they are stationary. Table D.9 shows the results of the unit root test carried out on the residuals from the domestic demand equation and indicates that, for this equation and dataset, there is evidence to suggest stationarity in the residuals.

Table D.10 indicates a strong degree of autocorrelation in the residuals from the domestic demand equation and thus evidence of serial correlation. This is perhaps to be expected given that panel data have been used and the equation specification contains no dynamics. There is, however, no impact on the point estimates obtained because the White Heteroskedasticity robust estimator has been used throughout the econometric analysis. The residuals from the trade equations exhibit similar properties to those from the domestic demand equation.

TABLE D.10: CORRELOGRAM OF THE RESIDUALS FROM THE DOMESTIC DEMAND EQUATION

	Autocorrelation	Partial correlation	Q-Statistic	Probability
1	0.36	0.36	24.38	0.00
2	0.23	0.11	33.76	0.00
3	-0.02	-0.16	33.86	0.00
4	-0.02	0.01	33.95	0.00
5	-0.07	-0.03	34.92	0.00
6	-0.03	0.00	35.14	0.00
7	-0.11	-0.10	37.36	0.00
8	-0.29	-0.28	53.82	0.00
9	-0.22	-0.01	62.79	0.00
10	-0.19	-0.04	69.74	0.00
11	-0.08	-0.03	70.98	0.00
12	-0.05	-0.04	71.54	0.00

Source(s): Cambridge Econometrics.

Conclusions

The parameters from the equations estimated for this sector seem, in general, quite reasonable. A somewhat peculiar result is the finding that the larger extra-EU importers' response to changes in the extra-EU import price is inelastic and driven by activity (intermediate demand) much more than price.

Appendix E: Manufacture of Plaster Products for Construction Purposes

Introduction

The Manufacture of Plaster Products for Construction Purposes industry is a NACE 4-digit industry (26.62 under NACE Rev 1.1[99] and 23.62 under NACE Rev 2[100]). It belongs to the Manufacture of Articles of Concrete and Plaster industry (26.6 Rev 1.1 and 23.6 Rev 2) which belongs to the broader NACE 2-digit industry of Manufacture of Other Non-Metallic Mineral Products (26 Rev 1.1 and 23 Rev 2).

Data Coverage

The table below summarises data availability for the Manufacture of Plaster Products for Construction Purposes industry. It should be noted that macro variables such as GDP are not reported in the table as they are general to all industries and contain a full set of data.

Price variables generally have the largest percentage of missing values, and the coverage does not improve much at NACE 3-digit level. Only at NACE 2-digit level does the coverage improve considerably.

TABLE E.1: DATA AVAILABILITY FOR THE MANUFACTURE OF PLASTER PRODUCTS FOR CONSTRUCTION PURPOSES INDUSTRY

	% of data points missing (1995-2007 * 27 EU Member States)		
	NACE four-digit	NACE three-digit	NACE two-digit
Domestic output price index	87.2	71.2	32.8
Producer price index	92	79.2	42.2
Production value	45.6	17.9	10.8
Wages and salaries	48.7	21.4	14.2
Number of persons employed	49.9	21.1	17.1
Extra-EU exports	31.3	31.1	30.8
Extra-EU imports	35.9	30.8	30.8

Source(s): Eurostat.

[99] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:006:0003:0034:EN:PDF

[100] http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NACE_REV2&StrLanguageCode=EN&IntPcKey=&StrLayoutCode=HIERARCHIC&CFID=777843&CFTOKEN=5902e1781799e86f-6E5AAE84-9E00-3409-87B3E71F52CDFE91&jsessionid=1e517066588cded2a4db23d356e502549443TR

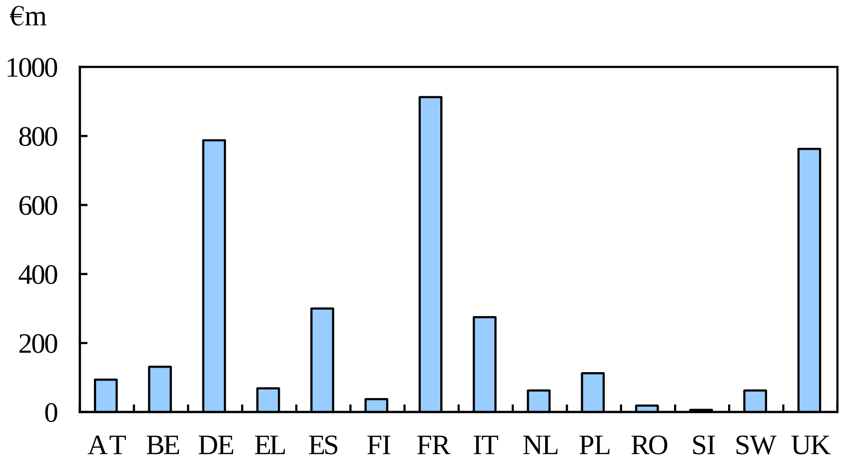
Data Analysis

Sample size

The sample size used for each of the equations differed, based on the availability and quality of the data for the variables specific to each equation. However, some of the excluded countries were common to all of the equations, due to a complete lack of data in key variables before the filling technique was carried out. These countries were as follows: Bulgaria, Czech Republic, Cyprus, Denmark, Estonia, Ireland, Latvia, Luxembourg, Malta, Portugal and Slovakia. For the domestic demand equation Hungary, Poland and Romania were further excluded from the estimation due to unusual data, leaving a sample of 13 cross-sections. No further countries needed to be excluded from the import demand equation, so this estimation consisted of a sample of 16 cross-sections. For the export demand equation all the new Member States were further removed, leaving a sample of 11 countries.

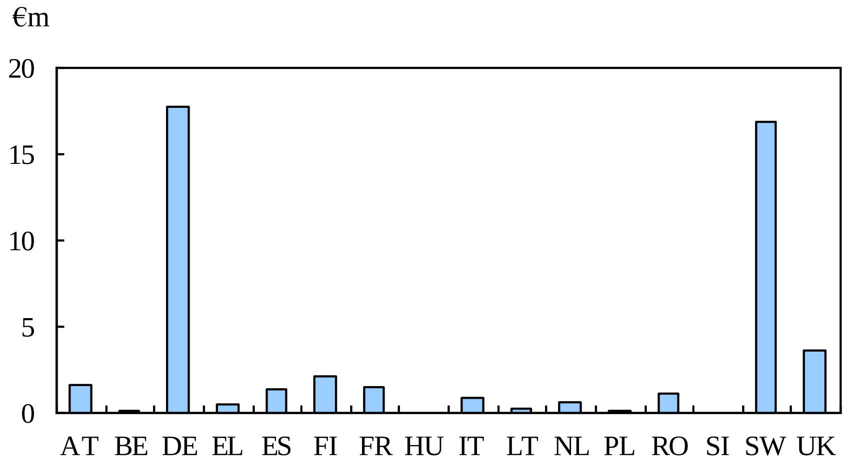
The charts below provide a snapshot of the European Plaster Products for Construction Purposes industry. Major producer countries are Germany, France, the UK, Spain and Italy. The main importer countries are Germany, Sweden and the UK while the main exporter countries are Germany and Poland.

CHART E.1: MEAN OF VALUE OF DOMESTIC DEMAND



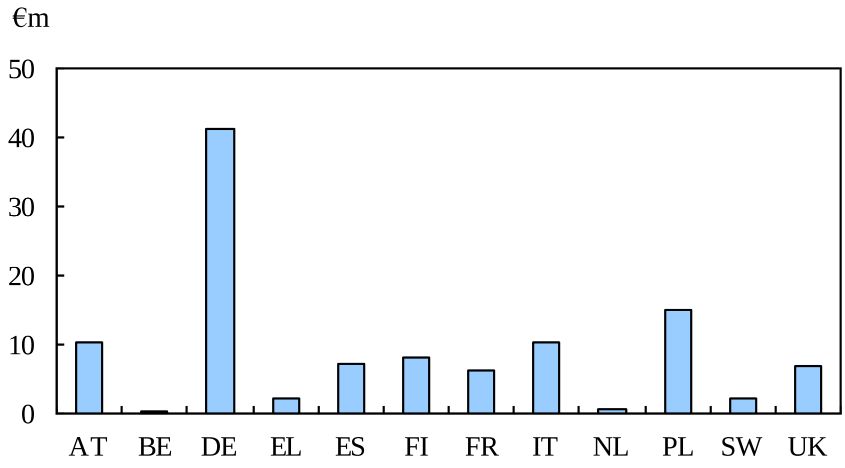
Note(s) : Figures are the means of domestic production less exports for each country over 1995-2007.
Source(s) : Eurostat.

CHART E.2: MEAN OF EXTRA-EU IMPORT VALUE



Note(s) : Figures are the means of extra-EU imports for each country over 1995-2007.
Source(s) : Eurostat.

CHART E.3: MEAN OF EXTRA-EU EXPORT VALUE



Note(s) : Figures are the means of domestic production for each country over 1995-2007.
Source(s) : Eurostat.

Table E.2 below shows that there is sufficient variation of the domestic price variable both between Member States and across time to allow it to be used as an explanatory variable in the presence of cross-section and period fixed effects.

TABLE E.2: VARIATION IN DOMESTIC PRICE INDEX (2005=100)

Country	Mean	Median	Maximum	Minimum	Standard deviation	# observations
AT	88.75	87.26	107.66	73.37	10.82	13.00
BE	92.66	93.49	108.42	80.23	9.19	13.00
DE	101.36	101.23	106.77	98.00	2.14	13.00
EL	87.13	87.84	110.05	65.23	13.98	13.00
ES	93.08	92.18	111.43	82.35	8.67	13.00
FI	95.69	96.02	109.45	86.94	6.46	13.00
FR	93.63	93.37	107.58	86.37	7.02	13.00
HU	81.00	85.34	107.73	53.48	19.54	13.00
IT	92.34	95.09	104.68	79.28	8.75	13.00
LT	102.62	107.55	127.50	79.03	13.07	13.00
NL	98.46	99.66	109.41	92.78	5.07	13.00
PL	92.04	99.34	113.66	63.48	14.28	13.00
RO	60.16	47.94	111.73	28.66	32.05	13.00
SI	80.15	78.88	110.58	54.73	18.62	13.00
SW	91.98	92.31	107.85	77.31	8.91	13.00
UK	92.93	91.37	108.65	81.43	7.87	13.00
All	90.25	93.99	127.50	28.66	16.31	208.00

Source(s): Eurostat.

The relationship between price and instruments

Table E.3 to E.5 below report the covariance and correlation between the endogenous variable in the equations and the instruments employed. This analysis allows us to assess whether the rank condition is satisfied. There appears to be a positive, statistically significant correlation between the domestic price and all of its instruments. It can be shown from the table that both the order and rank conditions are satisfied.

There appears to be a positive, statistically significant correlation between the extra-EU import price and its instrument, weighted industrial wages and salaries in non-EU countries. Both the order and rank conditions are satisfied.

There appears to be a negative, statistically significant correlation between the extra-EU export price and two of its instruments, namely wages and salaries and the number of persons employed. The relationship between the extra-EU export price and the producer price index is less clear. There seems to be some correlation between the price variable and the selected instrument, and this may be sufficient to satisfy the rank condition.

TABLE E.3: RELATIONSHIP BETWEEN THE DOMESTIC PRICE AND ITS INSTRUMENTS

	Covariance	Correlation	Probability
Domestic price	264.82	1.00	-
Wages and salaries	184.84	0.26	0.00
Producer price index	250.92	0.98	0.00
Employment	3717.50	0.20	0.00

Source(s): Eurostat, Cambridge Econometrics.

TABLE E.4: RELATIONSHIP BETWEEN THE EXTRA-EU IMPORT PRICE AND ITS INSTRUMENT

	Covariance	Correlation	Probability
Extra-EU import price	6858.78	1.00	-
Weighted industrial wages and salaries in non-EU countries	60628.44	0.23	0.00

Source(s): Eurostat, Cambridge Econometrics.

TABLE E.5: RELATIONSHIP BETWEEN THE EXTRA-EU EXPORT PRICE AND ITS INSTRUMENTS

	Covariance	Correlation	Probability
Extra-EU export price	141748.80	1.00	-
Wages and salaries	-2750.53	-0.17	0.01
Producer price index	-67.14	-0.01	0.87
Employment	-111443.10	-0.25	0.00

Source(s): Eurostat, Cambridge Econometrics.

Results

The Hausman test was conducted to assess whether there was evidence of endogeneity with respect to the price variable (see Chapter 4 for more details regarding this test). The null hypothesis of this test is that there is no endogeneity (i.e. there is no correlation between the variable and the error term).

In the case of the domestic demand equation the Hausman test rejected the null-hypothesis of no endogeneity. Producer prices were therefore used as an instrument in this estimation.

For the import demand equation, the Hausman test fails to reject the null-hypothesis of no endogeneity (p-value of 0.44) in the import demand equation.

In the case of the export demand equation, the Hausman test also failed to reject the null-hypothesis of no endogeneity (p-value of 0.78), so, again, no instruments were used in this equation.

The results reject the null-hypothesis that the country-specific fixed effects are jointly insignificant. Therefore it is justified to use cross-section fixed effects in domestic, import and export demand equations.

The results reject the null-hypothesis that the period fixed effects are jointly insignificant. Therefore it is justified to use period fixed effects in domestic, import and export demand equations.

TABLE E.6: ESTIMATION RESULTS FROM THE DOMESTIC DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	14.30	4.58	3.12	0.00
GDP	0.60	0.36	1.69	0.09
Domestic price index	-0.80	0.32	-2.47	0.01
R-squared	0.99			
Adjusted R-squared	0.99			
# instruments	1			

Source(s): Cambridge Econometrics.

For the domestic demand equation the dependent variable used was equal to output minus exports, in order to just pick up domestic demand for domestic production, instead of production for both domestic and external demand. It was found that the results from the equation using this as the dependent variable were better than when output alone was used.

Despite these improvements, the results from the estimation of the domestic demand equation, shown in Table E.6 are not of high-quality. The variables representing domestic price and GDP both have the correct coefficient sign, and are both statistically significant, at the 1% and 10% level respectively. However, the variances for these variables are very high relative to the size of the coefficients.

Furthermore, the explanatory variable for import prices had to be removed from the estimation, as the coefficient sign was theoretically implausible. Imports are regarded as a substitute for domestic goods, meaning when import prices increase we would expect to see domestic demand to increase also. The coefficient sign should therefore be positive. However, in this estimation the coefficient was negative.

TABLE E.7: ESTIMATION RESULTS FROM THE IMPORT DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	16.45	0.36	45.59	0.00
Extra-EU Import Price	-0.90	0.09	-9.52	0.00
R-squared	0.90			
Adjusted R-squared	0.89			
# instruments	0			

Source(s): Cambridge Econometrics.

The results from the estimation of the import demand equation are slightly better than the results of the domestic demand estimation, although they are still not of very high quality. Only one explanatory variable was included; the variable for import prices. The GDP variable was removed due to its incorrect coefficient sign, which in turn increased the coefficient for the domestic price variable to an unrealistic magnitude. Although this equation only has one parameter, the fixed effects used control for a lot of the variation, meaning the equation still has some merit. Furthermore, the variable for import prices is statistically significant at the 1% level and the variance is quite small in relation to the size of the coefficient. The R-squared coefficient is also reasonably high, suggesting the equation fits the data well.

In the export demand equation both explanatory variables are statistically significant at least at the 5% level. The coefficient signs for the variables are also correct and the variance for the export price variable is quite low in relation to the magnitude of the coefficient. Furthermore, the R-squared coefficient is relatively high.

TABLE E.8: ESTIMATION RESULTS FROM THE EXPORT DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	15.59	0.92	17.00	0.00
Extra-EU import price	0.37	0.08	4.96	0.00
Extra-EU export price	-0.56	0.25	-2.25	0.03
R-squared	0.93			
Adjusted R-squared	0.91			
#instruments	0			

Source(s): Cambridge Econometrics.

Diagnostic Tests

This is a test for stationarity in the residuals from the estimated equation and is used to assess whether the equation suffers from problems with time series persistence. The null hypothesis is non-stationarity and the alternative hypothesis is stationarity. The results for the domestic demand equation are given below; similar tests were performed for the trade equations. In the case of the domestic demand equation the null-hypothesis of non-stationarity can be rejected at the 1% level, suggesting time series persistence is not a problem. In the case of the import and export equations, there was not sufficient evidence to reject the null-hypothesis, meaning these equations may suffer with time series persistence.

TABLE E.9: UNIT ROOT TEST ON THE RESIDUALS FROM THE DOMESTIC DEMAND EQUATION

	Statistic	Probability	# cross sections	# observations
Levin, Lin & Chu test	-9.15	0.00	13	156

Note(s): The unit root test assumes a common unit root process.
Source(s): Cambridge Econometrics.

There is a strong autocorrelation in the residuals for the domestic demand equation. Similar results are found in the trade equations.

This suggests that there is serial correlation in the residuals which is to be expected owing to the omission of dynamics from the equation. However, it has no impact on the results owing to the use of the White Heteroskedasticity robust estimator.

TABLE E.10: CORRELOGRAM OF THE RESIDUALS FROM THE DOMESTIC DEMAND EQUATION

	Autocorrelation	Partial correlation	Q-Statistic	Probability
1	0.30	0.30	15.72	0.00
2	0.12	0.04	18.38	0.00
3	0.03	-0.02	18.58	0.00
4	-0.09	-0.12	20.12	0.00
5	-0.16	-0.11	24.43	0.00
6	-0.12	-0.03	26.90	0.00
7	-0.16	-0.10	31.31	0.00
8	-0.09	-0.01	32.62	0.00
9	-0.06	-0.05	33.35	0.00
10	-0.09	-0.09	34.92	0.00
11	-0.14	-0.13	38.33	0.00
12	-0.06	-0.02	38.91	0.00

Source(s): Cambridge Econometrics.

Conclusions

We can conclude that the results for the domestic demand and import demand equations for the Manufacture of Plaster Products for Construction Purposes are not good, and cannot tell us much about demand in the sector. In all three equations the variances of the variables are often large in comparison to the coefficients, suggesting a large degree of instability in the equations. Furthermore, a large number of countries have been excluded from the estimations, resulting in small cross-section samples, and in the domestic and import demand equations there are a small number of explanatory variables. The export demand equation is, however, of better quality. Despite this, both trade equations seem to suffer from problems with time series persistence.

A final point to note is that, owing to the general nature of the methodology, it was not possible to include industry-specific factors in these equations. It is important to note, however, that many industry-specific factors will have been captured by the cross-section or period specific effects (or indeed by the intercept). However, those industry-specific factors which vary between Member States and over time will have been excluded.

Appendix F: Manufacture of Other Inorganic Basic Chemicals

Introduction

The Manufacture of Other Inorganic Basic Chemicals 2413[101] is an economic activity classified at the NACE four-digit level. The sector belongs to the Manufacture of Basic Chemicals industry which, in turn belongs to the broader NACE two-digit industry of Manufacture of Chemicals and Chemical Products.

Data Coverage

Table F.1 summarises the data availability for a number of key variables relevant to the analysis at the NACE 2, 3 and 4-digit levels. Macro variables such as GDP are not reported in the table as they are general to all industries and have a full set of data.

TABLE F.1: DATA AVAILABILITY FOR MANUFACTURE OF MANUFACTURE OF INORGANIC CHEMICALS

	% missing data points out of a possible 351 (27 EU member states across 1995-2007)		
Variable	NACE 4	NACE 3	NACE 2
Employment	8%	4%	0%
Domestic Output Price	74%	67%	26%
Producer Price	77%	74%	26%
Wages & Salaries	11%	4%	0%
Domestic Production	11%	4%	0%
Import Volumes	0%	0%	0%
Export Volumes	0%	0%	0%
Extra-EU Import Prices	0%	0%	0%
Extra-EU Export Prices	0%	0%	0%

Source(s) : Eurostat, Cambridge Econometrics.

Domestic price variables have by far the most missing data at all NACE levels. Coverage of domestic output prices and producer prices are particularly poor at the 4 and 3-digit levels, and require extensive filling with NACE 2-digit data. However, there are considerable gaps even in the 2-digit data.

Import and export volumes and prices data are complete at the NACE 4-digit level, and require no filling. Other domestic variables, including employment, wages and salaries and production, have some missing values at the 4-digit level, but can be filled using 2-digit level data if desired. However, it will usually be preferable to omit countries from the estimation instead.

[101]http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_NOM_DTL_VIEW&StrNom=NACE_1_1&StrLanguageCode=EN&IntPcKey=584391&IntKey=584559&StrLayoutCode=HIERARCHIC&IntCurrentPage=1

Data Analysis

Sample Sizes

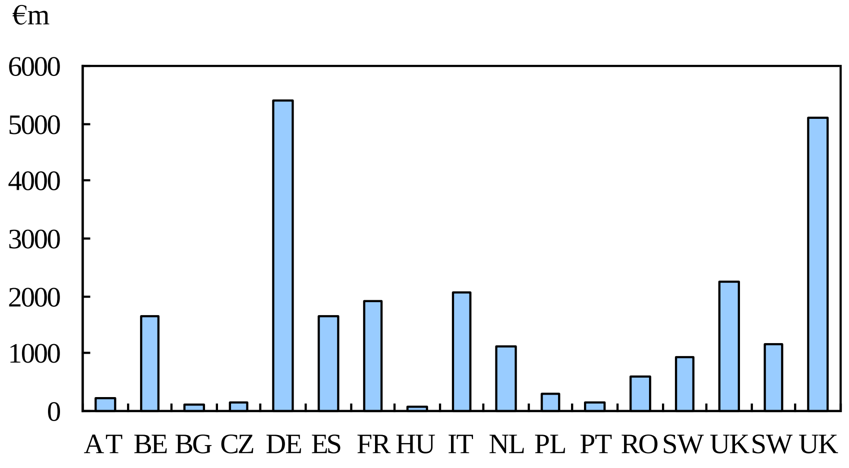
The data for each variable and country were examined for missing values and for strange and possibly spurious series. The data for a number of countries was dropped, generally due to missing (or zero) values.

Cyprus, Estonia, Finland, Latvia, Luxembourg, Malta and Slovakia were dropped from the domestic and import demand estimations, since the equations require domestic output prices, and this variable was unavailable for these countries even at the NACE 2-digit level. Furthermore, Lithuania was dropped from the domestic equations, since there were gaps in the data for wages & salaries, domestic output and employment at the 4-digit level, and filling using 2-digit level data produced odd results. These variables are not required for the import equations. Therefore, the sample size for the domestic equations is 351 - 13x8 = 247, and that for the import equations is 351 – 13x7 = 260.

In addition, producer prices (PPI) is a possible instrument for the domestic equations, but it has no data at any level for Portugal (as well as several other regions already excluded). Therefore, when PPI is used as an instrument, the domestic sample size comes down further to 234.

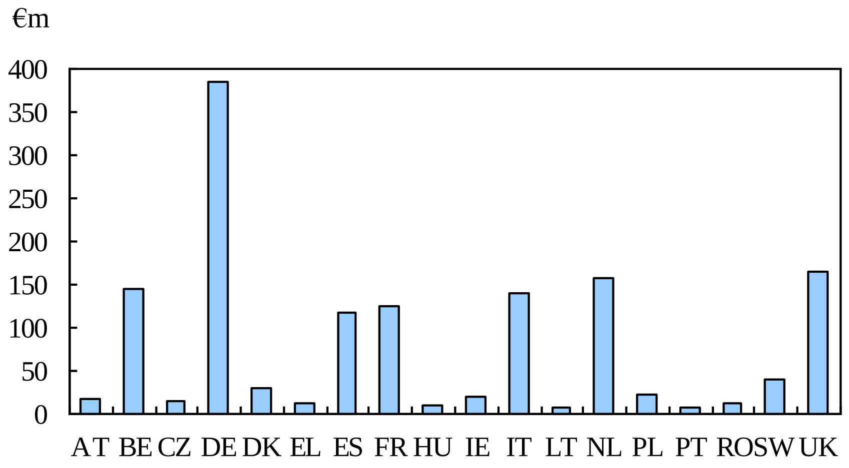
The export equations do not require domestic output price data. However, they use wages & salaries and employment as instruments, and therefore Latvia, Cyprus, Lithuania and Malta are excluded, since the former two have no data, and the later two only partial data. While they could be filled using NACE 2-digit data, it was considered that these countries were sufficiently small and few in number that the benefits of more reliable data outweighed the costs reduced degrees of freedom. In addition, Luxembourg is excluded, since the export price data are erratic and even drop below zero. With these countries excluded, the sample size is 351 – 13x5 = 273.

CHART F.1: MEAN OF VALUE OF DOMESTIC DEMAND



Note(s) : Figures are the means of domestic production less exports for each country over 1995-2007.
Source(s) : Eurostat.

CHART F.2: MEAN OF EXTRA-EU IMPORT VALUE

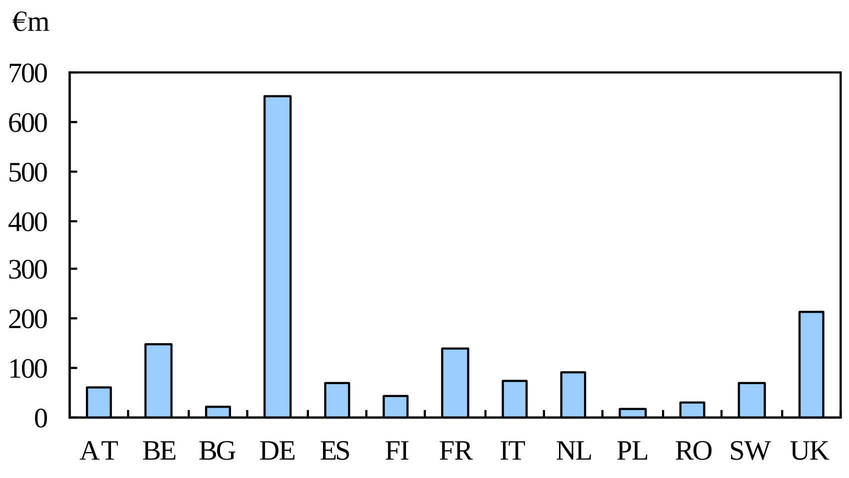


Note(s) : Figures are the means of extra-EU imports for each country over 1995-2007.
Source(s) : Eurostat.

In addition, PPI is again a possible instrument for the exports data, but data for Portugal and Slovakia is missing, in addition to the five countries above. Therefore, using PPI as an instrument brings the sample size down to 260.

The three charts F.1-F.3 show the mean levels over 1995-2007 of domestic demand, extra-EU import values and extra-EU export values in the Casting of Steel sector for each country. In all three cases, Germany is the largest player by far in the EU market. Therefore, a dummy variable for Germany will be considered for inclusion in the equations. It is also notable that, with the partial exception of Slovakia, all of the countries to be excluded from the equation sample have very small markets.

CHART F.3: MEAN OF EXTRA-EU EXPORT VALUE



Note(s) : Figures are the means of extra-EU imports for each country over 1995-2007.
Source(s) : Eurostat.

Variation in Prices

The following table suggests that there is sufficient variation in domestic output prices, both between Member States across time, for it to be suitable for estimation. Import and export prices were also sufficiently varied.

TABLE F.2: VARIATION IN DOMESTIC PRICES

Country	Mean	Median	Max	Min.	Std. Dev.	Obs.
AT	97.458	98.020	110.850	84.348	6.712	13
BE	90.334	89.910	109.160	78.970	10.424	13
BG	84.536	88.730	109.000	64.783	15.458	13
CZ	90.438	90.730	107.360	77.980	9.949	13
DE	96.842	96.460	110.510	88.590	6.529	13
DK	91.130	86.860	104.900	81.323	7.485	13
EL	86.192	84.190	101.820	76.050	10.368	13
ES	88.223	89.520	104.630	77.480	9.897	13
FR	96.369	94.580	109.450	88.440	6.407	13
HU	78.872	76.160	111.750	57.041	19.428	13
IE	89.158	92.010	102.090	78.720	8.533	13
IT	103.499	103.850	110.850	95.750	4.555	13
LT	90.209	87.920	122.290	68.848	14.686	13
NL	83.962	79.700	114.900	70.050	15.57	13
PL	102.717	98.700	145.427	87.633	16.434	13
PT	84.999	82.450	100.227	76.010	8.219	13
RO	63.581	54.880	113.870	34.676	29.207	13
SI	81.883	89.440	100.480	50.701	17.729	13
SW	86.722	85.590	105.400	43.580	15.883	13
UK	103.375	102.528	111.882	97.946	4.0277	13
All	89.525	91.610	145.428	34.676	15.744	260

Source(s) : Eurostat, Cambridge Econometrics.

Relationship between price and the instruments

The following tables show the covariance between domestic output prices, import prices and export prices and the various proposed instruments. They need to be significantly correlated in order for the assumptions behind instrument variable estimation to be valid.

TABLE F.3: RELATIONSHIP BETWEEN DOMESTIC PRICE AND ITS INSTRUMENTS

Instrument	Covariance	Correlation	Probability
Employment	-18093.510	-0.168	0.010
Producer Price Index	194.947	0.764	0.000
Wages & Salaries	821.282	0.221	0.001

Source(s) : Cambridge Econometrics.

There is statistically significant correlation between all instruments and the domestic price – so all instruments can be considered appropriate. There is also colineaity between employment and the other two instruments. This strengthens the cases for excluding PPI from the equation, which may be desirable since it would reduce the sample size and is heavily reliant on NACE 2-digit data.

TABLE F.4: RELATIONSHIP BETWEEN IMPORT PRICE AND ITS INSTRUMENT

Instrument	Covariance	Correlation	Probability
Extra-EU Weighted Wages & Salaries	271611.900	0.487	0.000

Source(s) : Cambridge Econometrics.

The correlation between the instrument and import prices is very strong and statistically significant, and therefore the instrument is suitable.

TABLE F.5: RELATIONSHIP BETWEEN EXPORT PRICE AND ITS INSTRUMENTS

Instrument	Covariance	Correlation	Probability
Employment	-53713.890	-0.093	0.146
Producer Price Index	219.179	0.158	0.013
Wages & Salaries	1248.412	0.0629	0.325

Source(s) : Cambridge Econometrics.

Producer prices are significantly correlated with export prices, but employment is insignificant at the 10% level and wages & salaries is very insignificant. Therefore, the suitability of employment and wages & salaries is questionable. For this equation, it may be better to use the filled producer prices data, despite concerns about the poor quality of data and reduction in sample size.

Functional Form Tests

Hausman test for endogeneity

A series of Hausman tests were conducted to assess whether there was evidence of endogeneity. The null hypothesis is that there is no endogeneity whereas the alternative hypothesis is that there is endogeneity. If endogeneity is present, instrument variable techniques are used in the final estimation. The results were as follows:

- *Domestic Demand*: Most versions of the domestic demand equation reject the null hypothesis that there is no endogeneity. However, some versions of the equation fail to reject the null hypothesis, generally when PPI is used as an instrument.
- *Import Demand*: The null hypothesis that there is no endogeneity is rejected with a high confidence level in all cases where fixed effects across countries are included. However, in the final version of the equation, in which the NACE 2-digit price index is used instead of the NACE 4-digit import price, the hypothesis was rejected.
- *Export Demand:* As for the import demand equation, the Hausman test rejected the hypothesis that there is no endogeneity for most specifications of this equation, but

did not do so for the final version of the equation, in which the NACE 2-digit price index is used.

Test for fixed effects Fixed effect techniques are used to control for unobserved variation across countries and time periods, but this comes at the cost of reducing the degrees of freedom. However, hypothesis tests that the impacts of the fixed effects techniques were insignificant were rejected in all cases, which justify their inclusion.

Results

Domestic demand The Hausman tests rejected the hypothesis that there is no endogeneity in cases where PPI was not included as an instrument. However, it was found that specifications of the domestic demand equation that used instrument variables but not PPI as an instrument had poor statistical and theoretical properties. Therefore, the final version of the equation does not use instrument variables,[102] there is no endogeneity and so instrument variables are not used. The final equation also drops the extra-EU import price, for which the coefficients were implausible and insignificant, and does not require any heterogeneity dummies:

TABLE F.6: ESTIMATION RESULTS FROM THE DOMESTIC DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		-11.411	4.485	-2.544	0.012
GDP		2.647	0.361	7.331	0.000
Domestic Price		-0.365	0.150	-2.426	0.016
R-squared	0.978				
Adjusted R-squared	0.974				
Instruments	None				

Source(s) : Cambridge Econometrics.

The estimate of price elasticity is theoretically plausible, at -0.42%, and it has good statistical properties, being significantly different from zero at a 2% confidence level. The coefficient on GDP is also plausible and significant. R^2 is high.

Import demand It was found that the use of trade prices data, which are a proxy series specified in €/100kg, generated results with poor statistical and theoretical properties. It is thought that this is a poor specification, given that the Inorganic Chemicals sector covers a large number of products with a variety of weights. This is especially the case where the composition of imports changes.

[102] As the Hausman test results suggest, there is actually little difference between the results when using instrument variables while including PPI as an instrument, and when dropping instrument variables altogether

Therefore, the trade prices were replaced with a trade price index at the NACE 2-digit level. In this case, the Hausman test cannot reject the hypothesis that there is no endogeneity, and therefore the final version of the equation does not use instrument variables. Domestic price and GDP were removed since their coefficients were negative and insignificantly different from zero, and heterogeneity dummies were not required:

TABLE F.7: ESTIMATION RESULTS FROM THE IMPORT DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		17.261	0.025	681.062	0.000
Extra-EU Import Prices		-0.315	0.148	-2.129	0.034
R-squared	0.980				
Adjusted R-squared	0.977				
Instruments	None				

Source(s) : Cambridge Econometrics.

The results shown in Table F.7 match our theoretical expectations well. The coefficient on import prices is negative and of a plausible size. The variables are significantly from zero and R^2 is high.

Export demand

Similarly to the import demand equation, for the export demand equation it was found that the use of trade prices specified in €/100kg generated results with poor theoretical and statistical properties, and so these were dropped from the final equation and replaced with a NACE 2-digit price index. In this case, the Hausman test fails to reject the hypothesis that there is no endogeneity, and therefore the final version of the equation does not use instrument variables:

TABLE F.8: ESTIMATION RESULTS FOR THE EXPORT DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		17.138	0.032	529.712	0.000
Extra-EU Export Price		-0.928	0.193	-4.808	0.000
R-squared	0.940				
Adjusted R-squared	0.931				
Instruments	None				

Source(s) : Cambridge Econometrics.

The coefficient on export prices is negative and of a large but plausible size. It is significantly different from zero at the 1% confidence level. R^2 is high.

Diagnostic Tests

The hypothesis that there is a unit root in the residuals of the domestic demand equations cannot be rejected by an Augmented Dicky Fuller (ADF test) as Table F.9

shows However, there is clearly correlation between the residuals, as shown by the correlogram (see Table F.10) and a plot of the residuals. This is to be expected, given the lack of dynamics in the equations.

This is also the case for the export demand equation. However, the hypothesis that there is a unit root in the residuals of the import equation is rejected. Even so, the correlogram and residual plot clearly show that there is time series persistence in the equation.

TABLE F.9: UNIT ROOT TEST

Method	Statistic	Probability*	Cross-sections	Observations
Augmented Dicky-Fuller	46.731	0.157	19	209

Note(s): * Probabilities for Fisher tests are computed using an asymptotic Chi –square distribution. All other tests assume asymptotic normality.
Source(s) : Cambridge Econometrics.

TABLE F.10: CORRELOGRAM OF THE RESIDUALS

	AC	PAC	Q-Stat	Probability
1	0.512	0.512	60.522	0.000
2	0.245	-0.022	74.503	0.000
3	0.055	-0.084	75.216	0.000
4	-0.083	-0.102	76.840	0.000
5	-0.111	-0.013	79.726	0.000
6	-0.116	-0.035	82.893	0.000
7	-0.158	-0.106	88.804	0.000
8	-0.241	-0.170	102.60	0.000
9	-0.203	-0.011	112.44	0.000
10	-0.192	-0.084	121.31	0.000
11	-0.129	-0.025	125.31	0.000

Source(s) : Cambridge Econometrics.

Conclusions

We have been able to obtain price elasticity estimates for the Manufacture of Other Inorganic Chemicals sector that are theoretically plausible and statistically significant, and therefore suitable for use in the model. However, in order to do so we have made sizeable deviations from our main methodology, dropping instrument variables for all three equations, and dropping fixed effects across countries for the two trade equations.

TABLE F.11: SUMMARY

		Domestic Equation		Import Equation		Export Equation	
NACE code	Sector	Domestic Price	Import Price	Import Price	Domestic Price	Export Price	Import Price
2413	Manufacture of Other Inorganic Chemicals	-0.365	N/A	-0.315	N/A	-0.928	N/A

Source(s) : Cambridge Econometrics.

Conclusions Appendix G: Manufacture of Bricks, Tiles etc.

Introduction

The Manufacture of Bricks, Tiles etc. 2640 is an economic activity classified at the NACE four-digit level. The sector belongs to the Manufacture of Clay Building Materials, which, in turn, belongs to the broader NACE two-digit industry of Manufacture of Other Non-metallic Mineral Products.

Data Coverage

Table G.1 summarises the data availability for a number of key variables relevant to the analysis at the NACE 2, 3 and 4-digit levels. Macro variables such as GDP are not reported in the table as they are general to all industries and have a full set of data.

TABLE G.1: DATA AVAILABILITY FOR MANUFACTURE OF BRICKS ETC.

	% missing data points out of a possible 351 (27 EU member states across 1995-2007)	
Variable	NACE 3	NACE 2
Employment	4%	0
Domestic Output Price	81%	22%
Producer Price	85%	16%
Wages & Salaries	4%	4%
Domestic Production	4%	0%
Import Volumes	4%	0%
Export Volumes	2%	0%
Extra-EU Import Prices	0%	0%
Extra-EU Export Prices	4%	0%

Source(s): Eurostat.

Domestic output and producer prices have by far the most missing data at all NACE levels. Coverage at the 3-digit level is so poor that extensive filling with 2-digit data is unavoidable. However, even the 2-digit data are incomplete, so we shall be forced to omit some countries from the estimation.

Most other variables have good but not complete coverage at the 3-digit level. In these cases, filling with 2-digit data is possible, but it will usually be preferable to omit countries from the estimation instead.

Data Analysis

Sample Sizes The data for each variable and country were examined for missing values and for strange and possibly spurious series. The data for a number of countries was dropped, generally due to missing (or zero) values.

Cyprus, Estonia, Latvia, Luxembourg, Malta and Slovakia were dropped from the domestic and import demand estimations, since the equations require domestic output prices, and this variable was unavailable for these countries even at the NACE 2-digit level. This leaves a sample size in both cases of 351 – 13x6 = 273

In addition, producer prices (PPI) is a possible instrument for the domestic equations, but it has no data at any level for Portugal, on top of the countries also missing domestic price data. Therefore, when PPI is used as an instrument, the domestic sample size comes down further to 260.

In addition, in the case of the import equation, data for weighted wages & salaries are not available in the year 2007. This cuts the sample size down to 252.

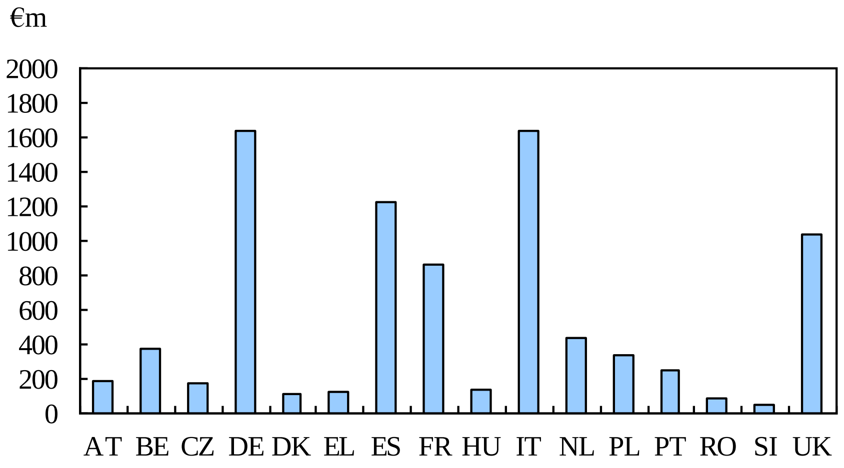
The export equations do not require domestic output price data. However, they use wages & salaries and employment as instruments, and therefore Luxembourg and Malta are excluded, since these countries have partially missing data and, in any case, zero wages & salaries or employment in those years that are available. In addition, export volumes data for Estonia are zero in some years and are therefore dropped. The export volumes data for Ireland are incomplete at the 3-digit level, and filling with 2-digit data produced odd results, therefore they were excluded. With these countries excluded, the sample size is 351 – 13x4 = 299.

As with the domestic equation, PPI is again a possible instrument for the exports data, but data for Cyprus, Latvia, Portugal and Slovakia are missing, on top of the four countries above. Therefore, using PPI as an instrument brings the sample size down to 247.

Mean production/import & export volumes

The three charts below show the mean levels over 1995-2007 of domestic demand, extra-EU import values and extra-EU export values in the Casting of Steel sector for each country[103].

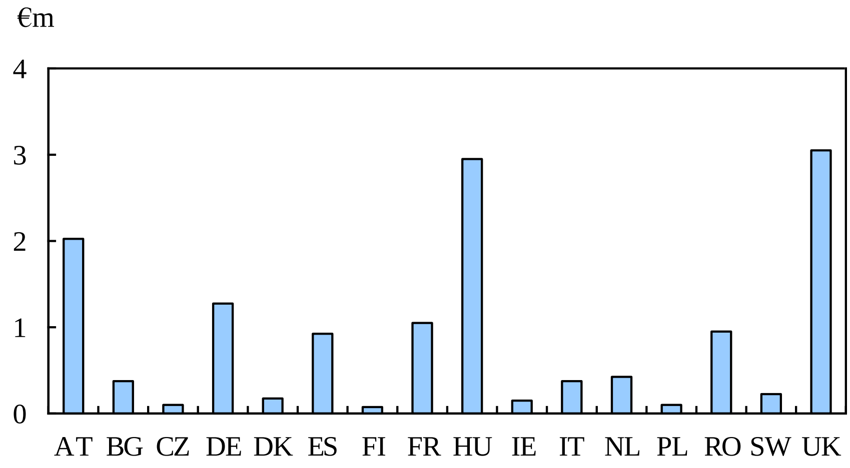
CHART G.1: MEAN OF VALUE OF DOMESTIC DEMAND



Note(s) : Figures are the means of domestic production less exports for each country over 1995-2007.
Source(s) : Eurostat.

[103] These charts show the 4-digit data once filled with 3-digit and 2-digit data

CHART G.2: MEAN OF EXTRA-EU IMPORT VALUE

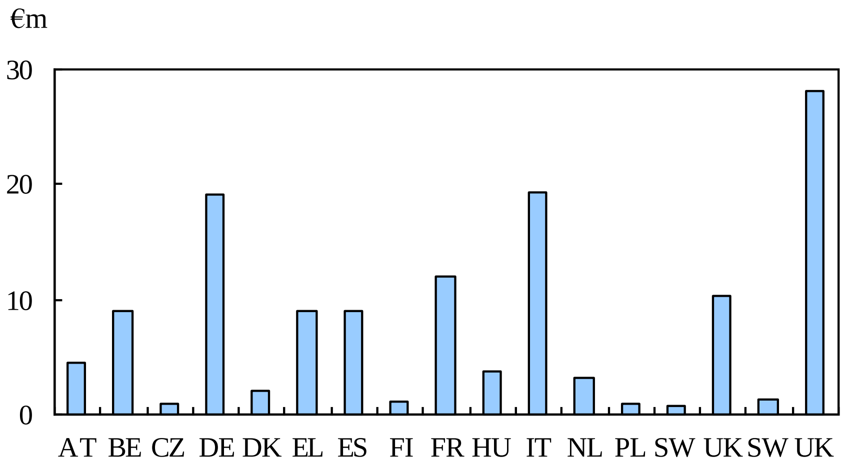


Note(s) : Figures are the means of extra-EU imports for each country over 1995-2007.
Source(s) : Eurostat.

Germany and Italy are the largest producers for domestic consumption in the EU. Therefore, a Germany/Italy dummy will be considered for inclusion in the domestic equation. Spain, France and the UK are also major producers.

The UK is the largest importer of cast steel in the EU, closely followed by Hungary Therefore, a Hungary/UK dummy will be considered for inclusion in the import equation.

CHART G.3: MEAN OF EXTRA-EU EXPORT VALUE



Note(s) : Figures are the means of extra-EU exports for each country over 1995-2007.
Source(s) : Eurostat.

The largest exporter of cast steel in the EU is the UK, followed by Germany and Italy Therefore, a Germany/Italy/UK dummy will be considered for inclusion in the export equation.

A further message to take from all three charts is that the countries being excluded from the estimation (see above) are all very minor players in the sector, in absolute terms, with the partial exception of Slovakia.

Variation in prices

The following table suggests that there is sufficient variation in domestic output prices, both between Member States and across time, to allow estimation of fixed cross-country and cross-period effects. Import and export prices were also sufficiently varied.

Relationship between price and the preferred instruments

TABLE G.2: VARIATION IN DOMESTIC PRICE

Country	Mean	Median	Max	Min.	Std. Dev.	Obs.
AT	88.751	87.260	107.660	73.372	10.817	13
BE	92.659	93.490	108.420	80.230	9.189	13
BG	87.808	88.890	114.490	72.719	13.424	13
CZ	92.131	96.830	106.820	70.440	10.960	13
DE	97.872	97.090	105.750	93.100	3.645	13
DK	89.682	86.740	114.510	78.131	10.645	13
EL	87.128	87.840	110.050	65.230	13.981	13
ES	89.428	94.060	110.880	66.800	15.238	13
FI	95.692	96.020	109.450	86.940	6.462	13
FR	85.147	84.610	108.070	66.240	14.098	13
HU	81.001	85.340	107.730	53.483	19.540	13
IE	90.536	88.760	110.110	78.220	10.429	13
IT	84.158	84.100	102.710	67.140	13.414	13
LT	102.618	107.550	127.500	79.027	13.074	13
NL	98.462	99.660	109.410	92.780	5.0675	13
PL	92.045	99.340	113.660	63.480	14.283	13
PT	96.541	95.402	103.590	89.580	4.005	13
RO	60.159	47.940	111.730	28.664	32.055	13
SI	80.150	78.880	110.580	54.725	18.615	13
SW	91.984	92.310	107.850	77.310	8.913	13
UK	86.461	83.070	108.820	71.850	12.605	13
All	89.067	92.860	127.500	28.664	15.783	273

Source(s): Eurostat, Cambridge Econometrics.

The following tables show the covariance between domestic output prices, import prices and export prices and the various proposed instruments. They need to be significantly correlated in order for the assumptions behind instrument variable estimation to be valid.

There is statistically significant correlation between PPI and employment and the domestic price, so these can be considered suitable instruments. Wages & salaries are also correlated, with a less strong confidence level. Therefore, all instruments appear to be suitable. Even so, there is a case for excluding PPI due to concerns about the lack of data at the NACE 3-digit level. All instruments are collinear with one another.

The correlation between the instrument and import prices is statistically significant at the 1% confidence level – easily enough to justify continuing with the estimation and using weighted wages & salaries as an instrument.

All potential instruments are significantly correlated at the 5% confidence level, and are suitable for use. Even so, there is a case for excluding PPI due to concerns about the quality of data.

Functional Form Tests

Hausman test for endogeneity

TABLE G.3: RELATIONSHIP BETWEEN DOMESTIC PRICE AND ITS INSTRUMENTS

Instrument	Covariance	Correlation	Probability
Employment	-12340.940	-0.171	0.006
Producer Price Index	232.775	0.935	0.000
Wages & Salaries	205.088	0.114	0.066

Source(s): Eurostat, Cambridge Econometrics.

TABLE G.4: RELATIONSHIP BETWEEN IMPORT PRICE AND ITS INSTRUMENT

Instrument	Covariance	Correlation	Probability
Extra-EU Weighted Wages & Salaries	59040.050	0.294	0.000

Source(s): Eurostat, Cambridge Econometrics.

TABLE G.5: RELATIONSHIP BETWEEN EXPORT PRICE AND ITS INSTRUMENTS

Instrument	Covariance	Correlation	Probability
Employment	7941.170	0.129	0.043
Producer Price Index	56.0250	0.259	0.000
Wages & Salaries	410.246	0.264	0.000

Source(s): Eurostat, Cambridge Econometrics.

A series of Hausman tests were conducted to assess whether there was evidence of endogeneity. The null hypothesis is that there is no endogeneity whereas the alternative hypothesis is that there is endogeneity. If endogeneity is present, instrument variable techniques are used in the final estimation. The results were as follows:

- *Domestic Demand*
  Most versions of the domestic demand equation reject the null hypothesis that there is no endogeneity with a high level of confidence. However, when PPI is included as an instrument, the Hausman test fails to reject the hypothesis by some margin.

Given that this is not the case for other instruments, this suggests that the PPI equation may be mis-specified, and PPI may not be suitable as an instrument.

- *Import Demand*
  The null hypothesis that there is no endogeneity is rejected with a very high confidence level of 1% in all cases where fixed effects across countries are included. However, in the final version of the equation, in which fixed effects were not used, the hypothesis was easily rejected.
- *Export Demand*
  The null hypothesis that there is no endogeneity is rejected with a very high confidence level of at least 5% in all cases.

Fixed Effect Tests Fixed effect techniques are used to control for unobserved variation across countries and time periods, but this comes at the cost of reducing the degrees of freedom. However, hypothesis tests that the impacts of the fixed effects techniques were insignificant were rejected in most cases, which justifies their inclusion. The exception was the time fixed effects in the export equation. However, fixed effects are retained as they are more theoretically sound than the alternative.

Results

Domestic Demand It was found that the domestic demand for bricks is driven almost entirely by construction output, rather than prices, presumably because there is little in the way of substitutes for bricks. All attempts to estimate the price effect returned a coefficient that was insignificantly different from zero and is of an implausible magnitude and/or sign. Therefore, the final domestic equation shown below includes only the effect of construction output on demand:

Construction output has a positive coefficient that is significantly different from zero at the 2% confidence level. R^2 is very high, confirming that construction output alone accounts for almost all of the variation in domestic demand.

Import Demand It proved challenging to produce plausible equations for import demand, probably because imports make up only 0.3% of total EU demand for bricks, and therefore import demand is a small and volatile variable. However, the results did indicate that, like the demand for domestic production, the demand for imports of Bricks is driven almost entirely by construction output. Estimates of the price elasticity had very poor

TABLE G.6: ESTIMATION RESULTS FOR THE DOMESTIC DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		15.164	1.449	10.465	0.000
Principal Industry Output		0.326	0.128	2.544	0.012
R-squared	0.987				
Adjusted R-squared	0.985				
Instruments	None				

Source(s): Cambridge Econometrics.

theoretical and statistical properties. Therefore, the final equation again only shows the impact of construction output on demand:

This equation provides evidence that construction output is an important factor in import demand. However, there remain some problems with the specification, in particular, the coefficient on construction output is rather high, while R^2 shows that this equation leaves some variation unexplained.

TABLE G.7: ESTIMATION RESULTS FOR THE IMPORT DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		-23.502	8.336	-2.819	0.005
Construction Output		3.127	0.740	4.229	0.000
R-squared	0.843				
Adjusted R-squared	0.820				
Instruments	None				

Source(s): Cambridge Econometrics.

Export demand

The export demand equation suffered from similar problems to the import equation. As exports comprise only 1.7% of mean EU production of bricks, the dependent variable is rather volatile. However, in this case it was possible to detect a significant price elasticity effect. The Hausman tests indicate that there is endogeneity, and so instrument variables are used. All three possible instruments are included in the final equation:

This equation has some good statistical properties. The coefficient on export price is significant at the 1% level of confidence and R^2 is reasonably high. The coefficient on export price has the expected sign, however, it is somewhat larger than we would expect. It may be that the volatile dependent variable prevents a very accurate estimation of the price elasticity.

Diagnostic Tests

TABLE G.8: ESTIMATION RESULTS FOR THE EXPORT DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		19.056	1.409	13.521	0.000
Extra-EU Export Prices		**-1.655**	0.523	-3.167	0.002
R-squared	0.874				
Adjusted R-squared	0.856				
Instruments	Employment, PPI, Wages & Salaries				

Source(s): Cambridge Econometrics.

The hypothesis that there is a unit root in the residuals of the domestic demand equations cannot be rejected by an ADF test (see table G.9). However, there is clearly correlation between the residuals, as shown by the correlogram (see table G.10) and a plot of the residuals. This is to be expected, given the lack of dynamics in the equations. Diagnostic tests also cannot reject the hypotheses that there are unit routes and serial correlation in the residuals of the import demand equation and serial correlation in the residuals of the export demand equation, although the ADF test narrowly rejects, at the 10% confidence level, the hypothesis that there is a unit root in the residuals of the export equation.

TABLE G.9: UNIT ROOT TEST

Method	Statistic	Probability*	Cross-sections	Observations
Augmented Dicky-Fuller	37.800	0.479	19	228

Note(s): * Probabilities for Fisher tests are computed using an asymptotic Chi –square distribution. All other tests assume asymptotic normality.
Source(s): Cambridge Econometrics.

TABLE G.10: CORRELOGRAM OF THE RESIDUALS

	AC	PAC	Q-Stat	Probability
1	0.630	0.630	99.124	0.000
2	0.350	-0.076	129.960	0.000
3	0.114	-0.125	133.260	0.000
4	-0.104	-0.176	135.970	0.000
5	-0.257	-0.136	152.790	0.000
6	-0.309	-0.055	177.180	0.000
7	-0.262	0.016	194.760	0.000
8	-0.238	-0.109	209.320	0.000
9	-0.185	-0.058	218.150	0.000
10	-0.119	-0.044	221.840	0.000
11	-0.066	-0.041	222.970	0.000

Source(s): Cambridge Econometrics.

Conclusions

It has not been possible to produce usable estimates of prices elasticities for the Manufacture of Bricks and Tiles sector. In the case of domestic and import demand, construction output was found to dominate, and it was not possible to produce sensible estimates of price elasticity. In the case of exports, an estimate of price elasticity was produced, but our confidence in it is limited.

TABLE G.11: SUMMARY

		Domestic Equation		Import Equation		Export Equation	
NACE code	Sector	Domestic Price	Import Price	Import Price	Domestic Price	Export Price	Import Price
2640	Manufacture of Bricks, etc.	N/A	N/A	N/A	N/A	-1.655	N/A

Source(s): Cambridge Econometrics.

Appendix H: Manufacture of Agricultural Tractors

Introduction

The Manufacture of Agricultural Tractors 2931 is an economic activity classified at the NACE four-digit level. The sector belongs to the Manufacture of Agricultural and Forestry Machinery, which, in turn, the broader NACE two-digit industry of Manufacture of Machinery and Equipment Not Elsewhere Classified.

Data Coverage

Table H.1 summarises the data availability for a number of key variables relevant to the analysis at the NACE 2, 3 and 4-digit levels. Macro variables such as GDP are not reported in the table as they are general to all industries and have a full set of data.

TABLE H.1: DATA AVAILABILITY FOR MANUFACTURE OF AGRICULTURAL TRACTORS

	% missing data points out of a possible 351 (27 EU member states across 1995-2007)		
Variable	NACE 4	NACE 3	NACE 2
Employment	9%	4%	0%
Domestic Output Price	100%	74%	16%
Producer Price	100%	74%	16%
Wages & Salaries	82%	4%	0%
Domestic Production	80%	4%	0%
Import Volumes	0%	0%	0%
Export Volumes	2%	0%	0%
Extra-EU Import Prices	1 %	0%	0%
Extra-EU Export Prices	0%	0%	0%

Domestic output and producer prices have by far the most missing data at all NACE levels. Coverage at the 4-digit level is non-existent, and coverage at the 3-digit level is so poor that extensive filling with 2-digit data is unavoidable. However, even the 2-digit data are incomplete, so we shall be forced to omit some countries from the estimation.

Domestic production and wages & salaries data coverage is also quite poor and the 4-digit level, and will require a mixture of filling and the omission of some countries. Most other variables have good but not complete coverage at the 4-digit level. In these cases, filling with 2-digit data is possible, but it will usually be preferable to omit countries from the estimation instead.

Data Analysis

Sample Sizes The data for each variable and country were examined for missing values and for strange and possibly spurious series. The data for a number of countries was dropped, generally due to missing (or zero) values.

Cyprus, Estonia, Ireland, Latvia, Luxembourg, Malta and Slovakia were dropped from the domestic and import demand estimations, since the equations require domestic output prices, and this variable was unavailable for these countries even at the NACE 2-digit level. This leaves a sample size in both cases of 351 – 13x7 = 260

There are also problems with the domestic production data. The data for Slovenia has zeros in it, and is eliminated from the domestic equations. Furthermore, the export data for Portugal and Lithuania are greater than those for domestic production. Clearly, there is a problem with the data for these countries, and they are also eliminated from the domestic equation. This brings the sample size down to 351 – 13x10 = 221.

In addition, producer prices (PPI) is a possible instrument for the domestic equations, but it has no data at any level for Austria, Greece or Switzerland. Therefore, when PPI is used as an instrument, the domestic sample size comes down further to 182. Similarly, the wages & salaries data for Belgium and the Netherlands features zeros, and cannot be included, bringing the sample size down to 195 (if PPI is not used). Clearly, the sample size is already rather weak, and, other things being equal, we would rather avoid bringing it down further by using these instruments.

In addition, in the case of the import equation, data for weighted wages & salaries are not available in the year 2007. This cuts the sample size down to 243.

The export equations do not require domestic output price data. However, they use wages & salaries and employment as instruments, and therefore Estonia, Ireland, Latvia, Luxembourg and Malta are excluded, since these countries have partially missing data and, in any case, zero wages & salaries or employment in most of those years that are available. The sample size is 351 – 13x5 = 299.

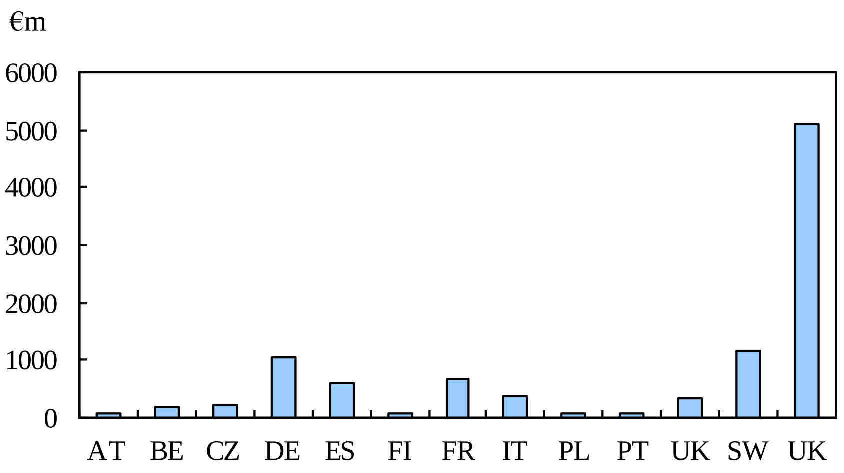
In addition, as noted above, the wages & salaries data for Belgium, the Netherlands and Slovenia include zeros, and so those countries are excluded if that instrument is used. Also, PPI is again a possible instrument for the exports data, but data for Austria, Greece or Switzerland are missing, on top of the countries above, and those countries must be omitted when that instrument is used.

Mean production/import & export volumes

The three charts below show the mean levels over 1995-2007 of domestic demand, extra-EU import values and extra-EU export values in the Casting of Steel sector for each country[104].

[104] These charts show the 4-digit data once filled with 3-digit and 2-digit data

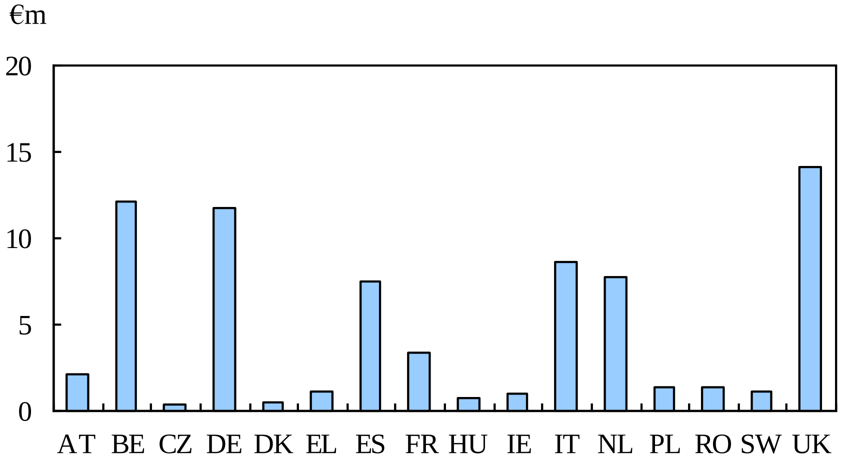
CHART C.1: MEAN OF VALUE OF DOMESTIC DEMAND



Note(s) : Figures are the means of domestic production less exports for each country over 1995-2007.
Source(s) : Eurostat.

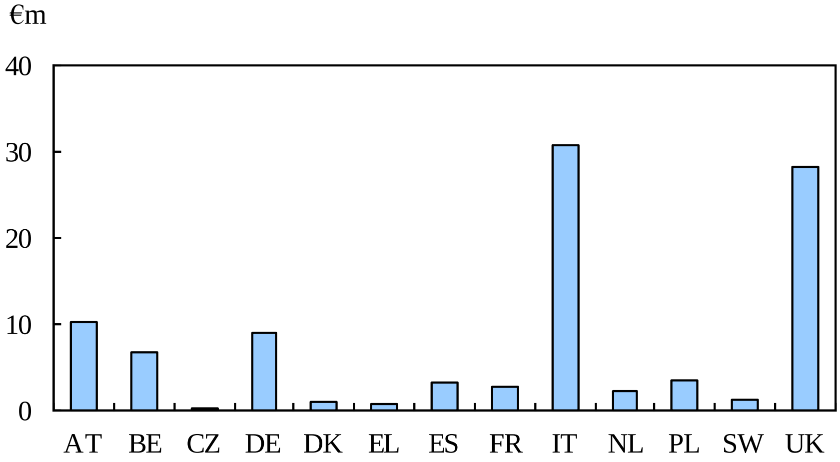
The UK is the largest producers for domestic consumption in the EU. Therefore, a UK dummy will be considered for inclusion in the domestic equation.

CHART C.2: MEAN OF EXTRA-EU IMPORT VALUE



Note(s) : Figures are the means of extra-EU imports for each country over 1995-2007.
Source(s) : Eurostat.

CHART C.3: MEAN OF EXTRA-EU EXPORT VALUE



Note(s) : Figures are the means of extra-EU exports for each country over 1995-2007.
Source(s) : Eurostat.

The UK is the largest importer of agricultural tractors in the EU, closely followed by Belgium, France and Germany. A UK dummy will be considered for inclusion in the import equation.

The largest exports by far are Italy and the UK, and a dummy for these countries will be considered for inclusion in the export equation.

A further message to take from all three charts is that the countries being excluded from the estimation (see above) are all very minor players in the sector, in absolute terms, with the partial exception of Slovakia.

Variation in prices

The following table shows the variation in domestic output prices, both between Member States across time. The variation is less than that for most other sectors, but estimation should be possible.

TABLE H.2: VARIATION IN DOMESTIC PRICE

Country	Mean	Median	Max	Min.	Std. Dev.	Obs.
AT	102.227	101.410	107.515	98.490	3.358	13
BG	89.421	92.280	111.110	72.707	12.269	13
CZ	92.509	94.310	104.080	75.060	8.409	13
DE	93.802	92.780	104.900	86.090	6.033	13
DK	84.192	85.920	108.580	57.700	16.859	13
EL	86.186	86.090	105.890	61.990	13.607	13
ES	89.947	89.480	108.240	74.950	9.799	13
FI	94.037	94.700	107.700	80.980	7.135	13
FR	89.983	87.640	105.420	79.760	8.454	13
IT	94.005	92.700	106.060	82.550	6.1592	13
PL	100.598	98.760	117.813	92.880	7.752	13
RO	65.288	52.080	115.340	37.048	29.3770	13
SW	97.445	97.500	105.210	90.910	4.444	13
UK	99.105	98.050	105.930	92.320	4.091	13
All	91.339	94.685	117.813	37.048	14.410	182

Source(s): Eurostat, Cambridge Econometrics.

Relationship between price and the preferred instruments

The following tables show the covariance between domestic output prices, import prices and export prices and the various proposed instruments. They need to be significantly correlated in order for the assumptions behind instrument variable estimation to be valid.

TABLE H.3: RELATIONSHIP BETWEEN DOMESTIC PRICE AND ITS INSTRUMENTS

Instrument	Covariance	Correlation	Probability
Employment	-12389.490	-0.233	0.0051
Producer Price Index	36.503	0.300	0.000
Wages & Salaries	317.248	0.212	0.011

Source(s): Cambridge Econometrics.

There is statistically significant correlation between all three instruments and the domestic price. Even so, there is a case for excluding PPI due to concerns about the quality of data. Most instruments are collinear with one another.

TABLE H.4: RELATIONSHIP BETWEEN IMPORT PRICE AND ITS INSTRUMENT

Instrument	Covariance	Correlation	Probability
Extra-EU Weighted Wages & Salaries	-5.700E+07	-0.258	0.000

Source(s): Cambridge Econometrics.

The correlation between the instrument and import prices is statistically significant at the 1% confidence level – easily enough to justify continuing with the estimation and using weighted wages & salaries as an instrument.

TABLE H.5: RELATIONSHIP BETWEEN EXPORT PRICE AND ITS INSTRUMENTS

Instrument	Covariance	Correlation	Probability
Employment	134062.500	0.115	0.110
Producer Price Index	15.074	0.003	0.967
Wages & Salaries	9594.990	0.303	0.000

Source(s): Cambridge Econometrics.

These are poor results. Employment is not correlated with the domestic price at the 10% confidence level, and there is almost no trace of a correlation between PPI and the domestic price. This calls into doubt the use of instrument variables to estimate the export demand equation. However, wages & salaries is correlated with the domestic price at the 1% confidence level.

Functional Form Tests

Hausman test for endogeneity

A series of Hausman tests were conducted to assess whether there was evidence of endogeneity. The null hypothesis is that there is no endogeneity whereas the alternative hypothesis is that there is endogeneity. If endogeneity is present, instrument variable techniques are used in the final estimation. The results were as follows:

- *Domestic Demand*
  Nearly all versions of the domestic demand equation reject the null hypothesis that there is no endogeneity with a greater than 1% level of confidence. An exception is where PPI is included as an instrument and heterogeneity dummies are not included, in which case the hypothesis that there is endogeneity cannot be rejected. This may be a mis-specified version of the equation.
- *Import Demand*
  The null hypothesis that there is no endogeneity cannot be rejected for any version of the import equation. We will therefore attempt estimation without instruments.
- *Export Demand*
  The null hypothesis that there is no endogeneity cannot be rejected for most versions of the export equation, which is an unsurprising result given the lack of correlation between the proposed instruments and the export price (see table H.5). We will therefore attempt estimation without instruments.

Fixed Effect Tests

Fixed effect techniques are used to control for unobserved variation across countries and time periods, but this comes at the cost of reducing the degrees of freedom. However, hypothesis tests that the impacts of the fixed effects techniques were insignificant were rejected in most cases, which justifies their inclusion. The exception was the time fixed effects in the export equation. However, fixed effects are retained as they are more theoretically sound than the alternative.

Results

Domestic Demand

It proved difficult to estimate meaningful or sensible equations for the domestic demand for agricultural tractors. Although the final equation below has coefficients that are reasonably consistent with economic theory, including the estimate of price elasticity, they are insignificantly different from zero. However, R^2 is high, even when industry output and domestic price are removed from the equation and the only remaining right-hand-side variable is a constant. This suggests that there is insufficient variable in domestic output to separate and identify the impacts of output and price. There were also several gaps in the data.

The best version of the domestic demand equation is shown below:

TABLE H.6: ESTIMATION RESULTS FOR THE DOMESTIC DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		19.046	4.183	4.553	0.000
Industry Output		0.127	0.355	0.358	0.721
Domestic Price		-0.441	0.374	-1.178	0.241
R-squared	0.960				
Adjusted R-squared	0.953				
Instruments	None				

Source(s): Cambridge Econometrics.

Import Demand

It proved challenging to produce plausible equations for import demand with respect to price, as almost all specifications returned spurious results such as a positive coefficient on import prices. The likely reasons for these poor results are similar to those for the poor results in the domestic demand equation: extra-EU imports of tractors is a small variable with little variation, and the reliability of the data is questionable.

The best possible specification of the equation is shown below:

Clearly, this result cannot be used to model carbon leakage from this sector, since the import price is not included, as it is found to be either insignificant or of the wrong sign in different specifications. However, this result is highly plausible in that it suggests that growth in agriculture is the primary driver of the demand for tractors.

TABLE H.7: ESTIMATION RESULTS FOR THE IMPORT DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		2.867	3.524	0.813	0.417
Output of principal demand industries		1.207	0.311	3.882	0.000
R-squared	0.884				
Adjusted R-squared	0.867				
Instruments	None				

Source(s): Cambridge Econometrics.

Export demand

Exports of tractors are somewhat larger than imports, and it was possible to estimate the price elasticity. The final equation, shown below, does not use instruments, and includes a heterogeneity dummy for the twelve EU states that have joined since 2004.

This equation has some good statistical properties. The coefficient on export price is significant at the 1% level of confidence and R^2 is high. The coefficient on export price also has the expected sign. The coefficient on the new Member States dummy implies that export demand in the new Member States is lower than in the rest of the EU. This coefficient is not significantly different from zero, but when it is removed the equation loses its other good statistical and theoretical properties. It should be noted that the data for the export equation suffer from similar problems to those for the domestic and import equations, which means that we cannot have too much confidence that these results are not spurious. Indeed, other, only slightly different, versions of the export equation returned very poor results.

TABLE H.8: ESTIMATION RESULTS FOR THE EXPORT DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		15.9584	0.0629	253.819	0.000
Extra-EU Export Prices * New States Dummy		0.678	0.637	1.064	0.289
Extra-EU Export Prices		-0.714	0.322	-2.216	0.028
R-squared	0.952				
Adjusted R-squared	0.944				
Instruments	None.				

Source(s): Cambridge Econometrics.

Diagnostic Tests

The hypothesis that there is a unit root in the residuals of the domestic demand equations cannot be rejected by an ADF test (see table H.9). However, there is clearly correlation between the residuals, as shown by the correlogram (see table H.10) and a plot of the residuals. This is to be expected, given the lack of dynamics in the equations. Diagnostic tests also cannot reject the hypotheses that there are unit routes and serial correlation in the residuals of the export demand equation and serial correlation in the residuals of the import demand equation, although the ADF test narrowly rejects, at the 10% confidence level, the hypothesis that there is a unit root in the residuals of the import equation.

TABLE H.9: UNIT ROOT TEST

Method	Statistic	Probability*	Cross-sections	Observations
Augmented Dicky-Fuller	31.882	0.279	14	154

Note(s): * Probabilities for Fisher tests are computed using an asymptotic Chi –square distribution. All other tests assume asymptotic normality.
Source(s): Cambridge Econometrics.

TABLE H.10: CORRELOGRAM OF THE RESIDUALS

	AC	PAC	Q-Stat	Probability
1	0.272	0.272	12.649	0.000
2	0.086	0.013	13.910	0.001
3	-0.034	-0.065	14.105	0.003
4	-0.195	-0.186	20.741	0.000
5	-0.113	-0.011	22.979	0.000
6	-0.116	-0.070	25.352	0.000
7	-0.109	-0.077	27.474	0.000
8	-0.094	-0.087	29.041	0.000
9	-0.094	-0.077	30.641	0.000
10	-0.054	-0.049	31.159	0.001
11	-0.014	-0.032	31.195	0.001

Source(s): Cambridge Econometrics.

Conclusions

It has not been possible to produce usable estimates of domestic and import price elasticities for the Manufacture of Agricultural Tractors sector. In the case of domestic demand, the coefficients were not significantly different from zero, and in the case of import demand, the coefficients on import price were spurious. In the case of exports, an estimate of price elasticity was produced, but our confidence in it is limited by our doubts about the quality of the data for this sector.

TABLE H.11: SUMMARY

		Domestic Equation		Import Equation		Export Equation	
NACE code	**Sector**	**Domestic Price**	**Import Price**	**Import Price**	**Domestic Price**	**Export Price**	**Import Price**
2640	Manufacture of Bricks, etc.	N/A	N/A	N/A	N/A	-0.714	N/A

Source(s): Cambridge Econometrics.

Appendix I: Manufacture of Motor Vehicles

Introduction

The Manufacture of Motor Vehicles 3410 is an economic activity classified at the NACE three-digit level. The sector is the main subsector in the broader NACE two-digit industry of Manufacture of Motor Vehicles, Trailers and Semi-Trailers.

Data Coverage

Table I.1 summarises the data availability for a number of key variables relevant to the analysis at the NACE 2, and 3-digit levels. Macro variables such as GDP are not reported in the table as they are general to all industries and have a full set of data.

TABLE I.1: DATA AVAILABILITY FOR MANUFACTURE OF MOTOR VEHICLES

	% missing data points out of a possible 351 (27 EU member states across 1995-2007)	
Variable	NACE 3	NACE 2
Employment	4%	4%
Domestic Output Price	70%	30%
Producer Price	78%	26%
Wages & Salaries	11%	4%
Domestic Production	13%	4%
Import Volumes	0%	0%
Export Volumes	0%	0%
Extra-EU Import Prices	0%	0%
Extra-EU Export Prices	0%	1%

Source(s): Eurostat.

Domestic output and producer prices have by far the most missing data at all NACE levels. Coverage at the 3-digit level is so poor that extensive filling with 2-digit data is unavoidable. However, even the 2-digit data are incomplete, so we shall be forced to omit some countries from the estimation.

Most other variables have good but not complete coverage at the 3-digit level. In these cases, filling with 2-digit data is possible, but it will usually be preferable to omit countries from the estimation instead.

Data Analysis

Sample Sizes

The data for each variable and country were examined for missing values and for strange and possibly spurious series. The data for a number of countries was dropped, generally due to missing (or zero) values.

Cyprus, Estonia, Latvia, Lithuania, Ireland, Luxembourg, Malta and Slovakia were dropped from the domestic and import demand estimations, since the equations require domestic output prices and this variable was unavailable for these countries even at the NACE 2-digit level. This leaves a sample size in both cases of 351 – 13x8 = 247

There are also issues to note on the domestic output data. Data for Denmark at the 3-digit level have zeros suggesting no domestic production (entirely plausible), and is therefore dropped from the estimation, while the data for Romania and the Czech Republic are filled using data at the 2-digit level. Additionally, Bulgaria, Finland and Slovenia must be eliminated from the sample for the domestic equation, since their exports are larger than their domestic production. This brings the sample size down to 351 – 13x12 = 195.

In addition, producer prices (PPI) is a possible instrument for the domestic equations, but it has no data at any level for Portugal, on top of the countries also missing domestic price data. Therefore, when PPI is used as an instrument, the domestic sample size comes down by a further 13.

In addition, in the case of the import equation, data for weighted wages & salaries are not available in the year 2007. This cuts the sample size for the imports equation down to 228. There are also numerous problems with the data for the intra-EU imports price, but it is better to leave that (minor) variable out altogether rather than reduce the sample size further.

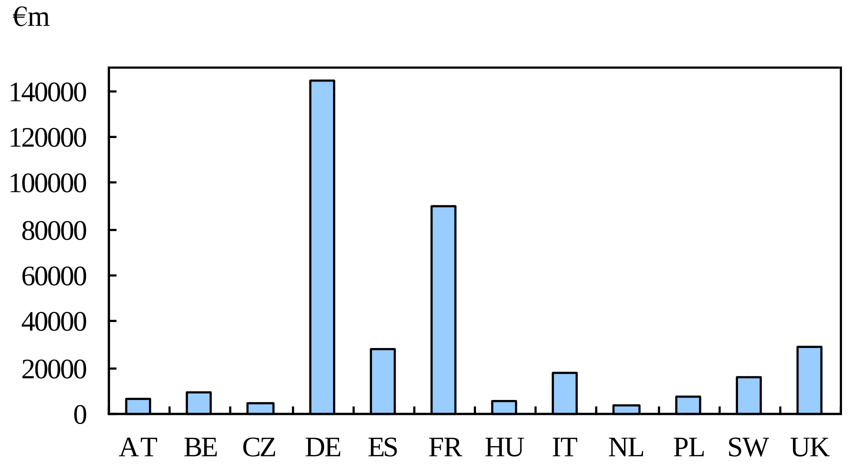
The export equations do not require domestic output price data. However, they use wages & salaries and employment as instruments, and therefore Denmark, Latvia and Luxembourg are excluded, since these countries have partially missing data and/or zeros. In addition, export volumes data for Ireland appear spurious, being very high in one year and very low in all other years, and are eliminated. Finally, export price data for Cyprus and Malta appear spurious and include zeros, and so those countries are eliminated. With these countries excluded, the sample size is 351 – 13x6 = 273.

As with the domestic equation, PPI is again a possible instrument for the exports data, but data for Estonia, Portugal and Slovakia are missing. Therefore, using PPI as an instrument brings the sample size down to 234.

Mean production/import & export volumes

The three charts below show the mean levels over 1995-2007 of domestic demand, extra-EU import values and extra-EU export values in the Manufacture of Motor Vehicles.

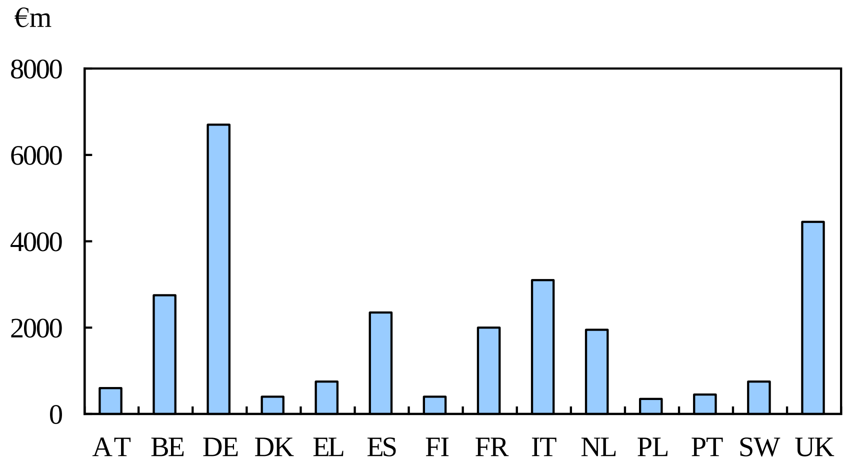
CHART I.1: MEAN OF VALUE OF DOMESTIC DEMAND



Note(s) : Figures are the means of domestic production less exports for each country over 1995-2007.
Source(s) : Eurostat.

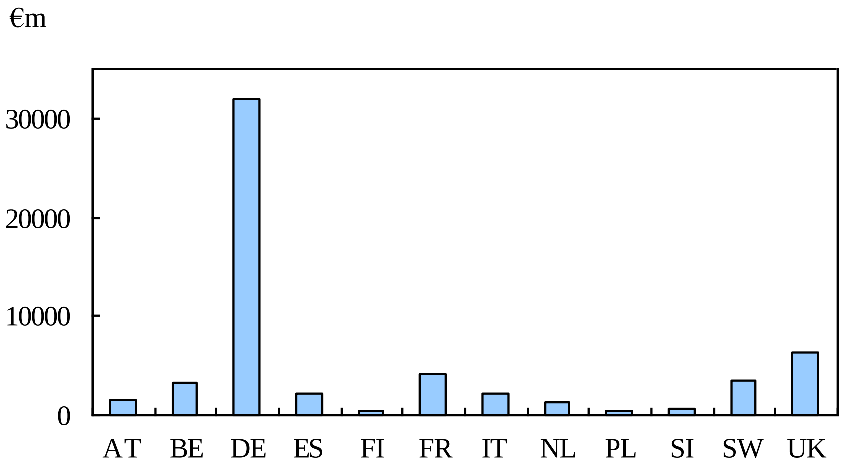
Germany is by far the largest producer for domestic consumption in the EU. Therefore, a Germany dummy will be considered for inclusion in the domestic equation. France is also a major producer.

CHART I.2: MEAN OF EXTRA-EU IMPORT VALUE



Note(s) : Figures are the means of extra-EU imports for each country over 1995-2007.
Source(s) : Eurostat.

CHART I.3: MEAN OF EXTRA-EU EXPORT VALUE



Note(s) : Figures are the means of extra-EU exports for each country over 1995-2007.
Source(s) : Eurostat.

Germany and the UK are the largest importers of motor vehicles in the EU. Therefore, country dummies for Germany and the UK will be considered for inclusion in the import equation.

The largest exporter of motor vehicles in the EU is again Germany. Therefore, a Germany dummy will be considered for inclusion in the export equation.

A further message to take from all three charts is that the countries being excluded from the estimation (see above) are all very minor players in the sector, in absolute terms, with the partial exception of Slovakia.

Variation in prices

The following table suggests that there is sufficient variation in domestic output prices, both between Member States and across time, to allow estimation of fixed cross-country and cross-period effects. Import and export prices were also sufficiently varied.

TABLE I.2: VARIATION IN DOMESTIC PRICE

Country	Mean	Median	Max	Min.	Std. Dev.	Obs.
AT	95.440	98.070	102.930	84.536	5.773	13
BE	102.404	103.350	104.900	98.800	2.343	13
BG	95.738	95.800	114.070	83.140	11.057	13
CZ	99.543	100.140	104.610	91.060	4.005	13
DE	94.415	93.820	102.240	86.800	5.093	13
DK	85.677	80.460	108.030	71.179	12.158	13
EL	92.092	92.800	102.960	76.370	8.498	13
ES	95.195	94.350	102.290	87.710	4.502	13
FI	97.405	97.070	107.960	91.220	4.511	13
FR	97.749	98.020	103.740	93.580	3.058	13
HU	79.786	87.520	108.930	26.463	26.066	13
IT	93.516	93.370	105.410	81.810	6.872	13
NL	94.791	94.190	104.340	87.030	5.406	13
PL	86.844	88.949	100.010	62.402	11.194	13
PT	98.528	100.745	119.920	64.065	13.460	13
RO	65.288	53.870	111.790	33.405	31.405	13
SI	80.239	82.450	101.730	50.117	19.423	13
SW	97.402	97.140	102.400	92.570	2.599	13
UK	101.400	101.220	105.225	98.669	2.393	13
All	92.287	96.240	119.920	26.463	14.886	13

Source(s): Eurostat, Cambridge Econometrics.

Relationship between price and the preferred instruments

The following tables show the covariance between domestic output prices, import prices and export prices and the various proposed instruments. They need to be significantly correlated in order for the assumptions behind instrument variable estimation to be valid.

TABLE I.3: RELATIONSHIP BETWEEN DOMESTIC PRICE AND ITS INSTRUMENTS

Instrument	Covariance	Correlation	Probability
Employment	205427.200	0.120	0.140
Producer Price Index	175.166	0.829	0.000
Wages & Salaries	11023.480	0.120	0.108

Source(s): Eurostat, Cambridge Econometrics.

There is statistically significant correlation between PPI and the domestic price at the 1% level of confidence. The correlations between employment and wages & salaries and the domestic price narrowly fail significant tests at the confidence level of 10%. Therefore, on this analysis, PPI is the most suitable instrument. Even so, there is a case for excluding PPI due to concerns about the lack of data at the NACE 3-digit level.

TABLE I.4: RELATIONSHIP BETWEEN IMPORT PRICE AND ITS INSTRUMENT

Instrument	Covariance	Correlation	Probability
Extra-EU Weighted Wages & Salaries	1249477.0	0.444	0.000

Source(s): Eurostat, Cambridge Econometrics.

The correlation between the instrument and import prices is statistically significant at the 1% confidence level – easily enough to justify continuing with the estimation and using weighted wages & salaries as an instrument.

TABLE I.5: RELATIONSHIP BETWEEN EXPORT PRICE AND ITS INSTRUMENTS

Instrument	Covariance	Correlation	Probability
Employment	18991662.0	0.456	0.000
Producer Price Index	811.4	0.162	0.013
Wages & Salaries	891035.5	0.442	0.000

Source(s): Eurostat, Cambridge Econometrics.

All potential instruments are significantly correlated with export prices at the 5% confidence level, and are suitable for use. Even so, there is a case for excluding PPI due to concerns about the quality of data.

Functional Form Tests

Hausman test for endogeneity

A series of Hausman tests were conducted to assess whether there was evidence of endogeneity. The null hypothesis is that there is no endogeneity whereas the alternative hypothesis is that there is endogeneity. If endogeneity is present, instrument variable techniques are used in the final estimation. The results were as follows:

- *Domestic Demand*
  Most versions of the domestic demand equation reject the null hypothesis that there is no endogeneity with a very high level of confidence. There are only a handful of very specific exceptions, in cases where the equation is probably misspecified.
- *Import Demand*
  The null hypothesis that there is no endogeneity cannot be rejected for all versions of the import demand equation at the 10% level of confidence.
- *Export Demand*
  The null hypothesis that there is no endogeneity cannot be rejected for most versions of the import demand equation at the 10% level of confidence.

Fixed Effect Tests

Fixed effect techniques are used to control for unobserved variation across countries and time periods, but this comes at the cost of reducing the degrees of freedom. However, hypothesis tests that the impacts of the fixed effects techniques were insignificant were rejected in all cases, which justify their inclusion.

Results

Domestic Demand

The Hausman test rejected the hypothesis that there is no endogeneity, and so instrument variables were used to estimate the domestic equation. Only PPI is a suitable instrument, as employment and wages and salaries are not sufficiently correlated with the domestic price. It was found that income, import prices and domestic prices all have an important impact on the demand for domestic production of motor vehicles. The final equation is shown below:

TABLE I.6: ESTIMATION RESULTS FOR THE DOMESTIC DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		16.365	2.048	7.989	0
Industry Output of Principal Demand Industries		0.496	0.181	2.748	0.007
Extra-EU Import Price		0.313	0.194	1.611	0.109
Domestic Price		**-0.341**	0.203	-1.678	0.095
R-squared	0.983				
Adjusted R-squared	0.980				
Instruments	PPI				

Source(s): Cambridge Econometrics.

All the variables in this equation have plausible coefficients with the 'correct' sign. The domestic price elasticity is around -0.34% and is just significantly different from zero at the 10% level of confidence. R^2 is very high, implying that this equation covers almost all the variation in domestic production.

Import Demand

The Hausman test cannot reject the hypothesis that there is no endogeneity, and so the final version of the equation does not use instrument variables. As with the domestic demand equation, it was found that income, import prices and domestic prices all have an important impact on the demand for imports of motor vehicles:

TABLE I.7: ESTIMATION RESULTS FOR THE IMPORT DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		-7.580	5.268	-1.439	0.152
Industry Output of Principal Demand Industries		2.411	0.456	5.292	0.000
Extra-EU Import Price		0.574	0.144	3.983	0.000
Domestic Price		**-0.836**	0.158	-5.287	0.000
R-squared	0.959				
Adjusted R-squared	0.952				
Instruments	None				

Source(s): Cambridge Econometrics.

All the variables in this equation have coefficients with the 'correct' sign, although the estimates are a little larger in magnitude than expected. The import price elasticity is around -0.8% and is easily significantly different from zero. R^2 is high.

Export demand

It proved challenging to produce plausible equations for export demand with respect to price, as almost all specifications returned spurious results such as a positive coefficient on import prices. It is not clear why this should be so, but there are some indications that the export data from new EU Member States is poor and highly volatile. Introducing a dummy for these countries, or, alternatively, removing them from the sample altogether, enables the export price elasticity for the remaining countries (covering over 95% of Extra-EU motor vehicles exports in the data) to be estimated. The case where the new Member States are excluded is shown below:

TABLE I.8: ESTIMATION RESULTS FOR THE EXPORT DEMAND EQUATION

Variable		Coefficient	Standard deviation	t-Statistic	Probability
Constant		21.098	0.018	1148.664	0.000
Extra-EU Export Price		**-0.200**	0.130	-1.537	0.127
R-squared	0.992				
Adjusted R-squared	0.990				
Instruments	None				

Source(s): Cambridge Econometrics.

The estimated price elasticity is plausible, at -0.2%, but it narrowly fails a significance test at the 10% confidence level. R^2 is very high, implying that this equation covers almost all the variation in domestic production.

Diagnostic Tests

The hypothesis that there is a unit root in the residuals of the domestic demand equations cannot be rejected by an ADF test (see table G.9). However, there is clearly correlation between the residuals, as shown by the correlogram (see table G.10) and a plot of the residuals. This is to be expected, given the lack of dynamics in the equations. Diagnostic tests also cannot reject the hypotheses that there are unit routes and serial correlation in the residuals of the import demand equation and serial correlation in the residuals of the export demand equation, although the ADF test rejects the hypothesis that there is a unit root in the residuals of the export equation.

TABLE I.9: UNIT ROOT TEST

Method	Statistic	Probability*	Cross-sections	Observations
Augmented Dicky-Fuller	23.989	0.243	10	120

Note(s): * Probabilities for Fisher tests are computed using an asymptotic Chi –square distribution. All other tests assume asymptotic normality.
Source(s): Cambridge Econometrics.

TABLE I.10: CORRELOGRAM OF THE RESIDUALS

	AC	PAC	Q-Stat	Probability
1	0.567	0.567	43.434	0.000
2	0.174	-0.217	47.575	0.000
3	-0.018	-0.024	47.621	0.000
4	-0.148	-0.134	50.637	0.000
5	-0.207	-0.074	56.624	0.000
6	-0.216	-0.082	63.156	0.000
7	-0.214	-0.098	69.600	0.000
8	-0.156	-0.020	73.100	0.000
9	-0.050	0.019	73.400	0.000
10	-0.082	-0.184	74.400	0.000
11	-0.092	-0.029	75.700	0.000
12	-0.058	-0.049	76.200	0.000

Source(s): Cambridge Econometrics.

Conclusions

The parameter estimates obtained for this sector were mixed. The price elasticities of demand for domestic production and imports are plausible and significant, and should be usable in the sector model. However, there is less confidence in our estimate of the price elasticity of export demand. In order to produce it, we had to drop a large number of countries from the sample, and even then the estimate was not significantly different from zero with a high level of confidence.

TABLE I.12: SUMMARY

		Domestic Equation		**Import Equation**		**Export Equation**	
NACE code	**Sector**	**Domestic Price**	**Import Price**	**Import Price**	**Domestic Price**	**Export Price**	**Import Price**
3410	Manufacture of Motor Vehicles	-0.341	0.313	-0.836	0.574	-0.200	N/A

Note(s): Export elasticity only estimated over EU15.
Source(s): Cambridge Econometrics.

Appendix J: Manufacture of Lime

Sector description

The Manufacture of Lime is an economic activity classified at the NACE four-digit level. It covers the manufacture of quicklime, staked lime and hydraulic lime. It also covers the production of calcined dolomite. It has the four-digit code 2652 in NACE Rev 1.1[105].

Data coverage

The most notable gaps in the data at the NACE four-digit level are in the domestic output price index and producer price index series, for which only 10-20% of the series are actual data. By contrast the output and labour data are substantially more complete and the extra-EU export and import series only have small gaps. There is a small improvement in the availability of the price data at the three-digit level and a substantial improvement at the two-digit level (see Table J.1).

Data analysis

Table J.1 highlights the paucity of price data available for this sector at the NACE four-digit level (amounting to a mere five countries out of 27). The implication is that data from a more aggregated classification may be necessary to produce a large enough dataset for the purposes of estimation. Thus, where data at the four-digit level of detail are available, they are used; where such data are missing, data at the three and two-digit levels are used instead. Moreover, in the trade series many of the values are zeros for a number of countries and for a number are zero throughout the sample period.

In total, eight countries were excluded from the estimation sample owing to a

TABLE J.1: DATA AVAILABILITY FOR THE MANUFACTURE OF LIME

	% of data points missing (1995-2007 * 27 EU Member States)		
	NACE four-digit	NACE three-digit	NACE two-digit
Domestic output price index	0.83	0.70	0.22
Producer price index	0.85	0.78	0.26
Production value	0.31	0.56	0.00
Wages and salaries	0.32	0.15	0.00
Number of persons employed	0.30	0.11	0.00
Extra-EU exports	0.07	0.00	0.00
Extra-EU imports	0.01	0.00	0.00
Extra-EU export prices	0.11	0.00	0.00
Extra-EU import prices	0.00	0.00	0.00

Source(s): Eurostat.

105 http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_NOM_DTL_VIEW&StrNom=NACE_1_1&StrLanguageCode=EN&IntPcKey=587583&IntKey=587695&StrLayoutCode=HIERARCHIC&IntCurrentPage=1

complete lack of output data (the production value series) at the NACE four-digit level: Bulgaria, the Czech Republic, Denmark, Estonia, Ireland, Malta, the Netherlands and Sweden. In the absence of any data at this level of detail, the data-filling approach described in Chapter 4 of this report cannot be applied.

A further four countries (Austria, Finland, Latvia, and Luxembourg) were excluded from the sample because of zero output (which is distinct from the missing data described in the previous paragraph), implying no domestic Lime sector.

Slovakia was excluded from the sample because the domestic price data are missing at all levels of NACE detail.

Cyprus was also dropped from the estimation sample. For this country, output was either zero, small, or missing. The filling procedure was found to perform poorly on a number of series relating to this country and sector and the resulting series were not considered suitable for inclusion in the final sample.

Data on the producer price index were not available at any level of NACE detail for Portugal. This data series was used as an instrument in the estimation of the domestic demand equation and Portugal was thus excluded from the estimation of this particular equation. The sample was the same for the estimation of the domestic demand equation, import demand equation and export demand equation.

In total, fifteen countries were excluded from the estimation sample: 56% (195) of the potential observations.

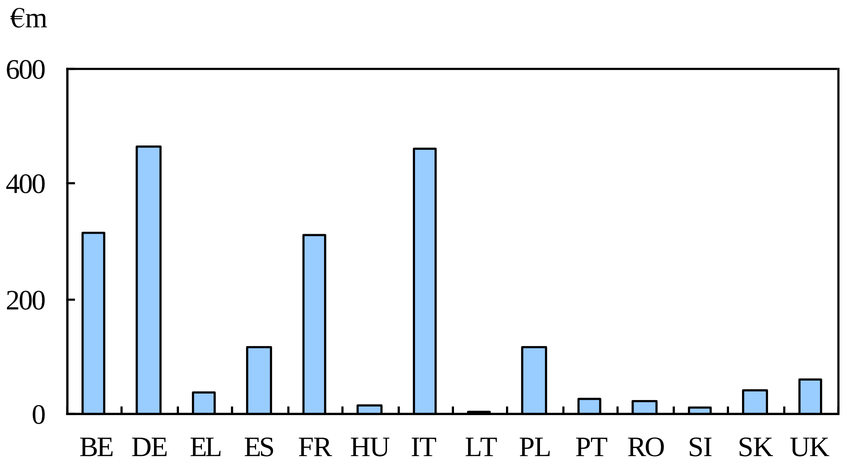
Chart J.1 shows a clear distinction between large and small demanders of Lime.

Belgium, Germany, France, and Italy can be considered large domestic markets in terms of domestic demand for domestic production, the others small.

Chart J.2 shows that no country imports much Lime from outside of the EU; total imports for the sector are just 0.4% of EU production.

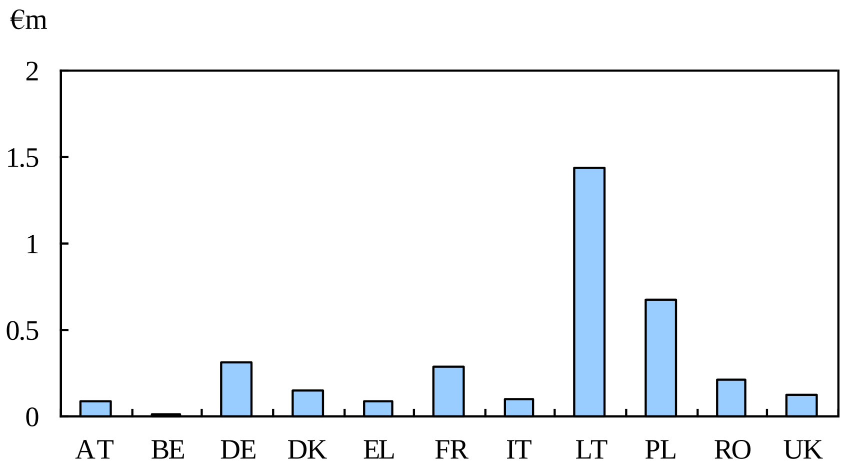
Chart J.3 shows total extra-EU export volumes to be small, equivalent to just 2% of total production. The UK and France are the largest extra-EU exporters.

CHART J.1: MEAN OF DOMESTIC DEMAND



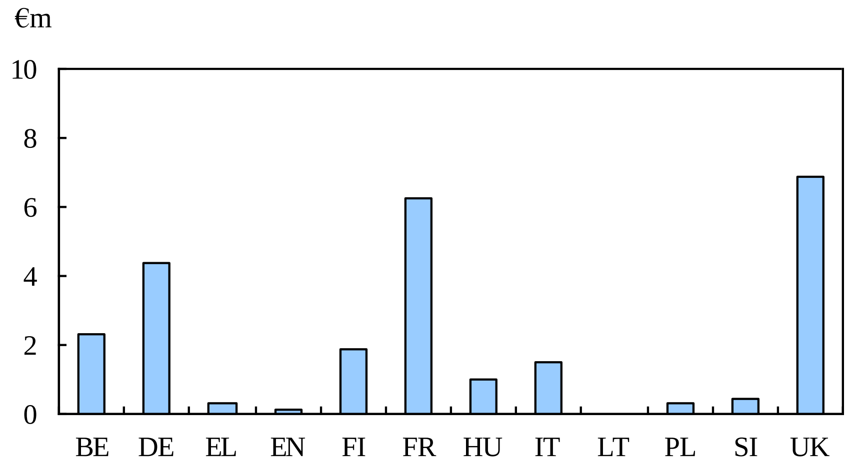
Note(s) : Figures are the means of domestic production less exports for each country over 1995-2007.
Source(s) : Eurostat.

CHART J.2: MEAN OF EXTRA-EU IMPORT VALUE



Note(s) : Figures are the means of extra-EU imports for each country over 1995-2007.
Source(s) : Eurostat.

CHART J.3: MEAN OF EXTRA-EU EXPORT VALUE



Note(s) : Figures are the means of domestic production for each country over 1995-2007.
Source(s) : Eurostat.

Table J.2 contains various descriptive statistics for the domestic price data series for the countries used in the estimation of the domestic demand equation and suggests that while there is sufficient variation in the series, both within and between countries, for it to be suitable for estimation.

The relationship between the domestic price and the instruments can be seen in Table J.3.

The analysis suggests that employment is a weaker instrument while the others exhibit statistically significant correlation at the 5% level, with the relationship between the

TABLE J.2: VARIATION IN DOMESTIC PRICES (2005=100)

	Mean	Median	Maximum	Minimum	Standard deviation	# observations
BE	92.66	93.49	108.42	80.23	9.19	13
DE	94.68	92.70	104.79	89.68	4.97	13
EL	89.57	88.89	106.19	68.32	10.32	13
ES	93.08	92.18	111.43	82.35	8.67	13
FR	98.29	96.42	125.95	80.77	15.73	13
HU	81.00	85.34	107.73	53.48	19.54	13
IT	89.39	86.66	116.39	73.65	12.94	13
LT	102.62	107.55	127.50	79.03	13.07	13
PL	92.04	99.34	113.66	63.48	14.28	13
RO	60.16	47.94	111.73	28.66	32.05	13
SI	80.15	78.88	110.58	54.73	18.62	13
UK	91.91	91.37	108.65	68.11	10.05	13

Source(s): Eurostat, Cambridge Econometrics.

domestic price and the producer price index particularly strong. The order and rank conditions can be considered satisfied.

Table J.4 shows the relationship between the extra-EU import price and its instrument.

The level of correlation found between the extra-EU import price and its instrument, weighted wages and salaries, was statistically insignificant. The instrument is not considered suitable for use in the estimation.

In the case of extra-EU export price, the order and rank conditions would seem to be satisfied for the producer price index, but correlation between the export price and the other candidate instruments is, statistically, not different from zero (see Table J.5).

TABLE J.3: RELATIONSHIP BETWEEN THE DOMESTIC PRICE AND ITS INSTRUMENTS

	Covariance	Correlation	Probability
Domestic price	336.47	1.00	-
Wages and salaries	93.52	0.20	0.01
Producer price index	309.68	0.94	0.00
Employment	-2727.96	-0.15	0.06

Source(s): Eurostat, Cambridge Econometrics.

TABLE J.4: RELATIONSHIP BETWEEN THE EXTRA-EU IMPORT PRICE AND ITS INSTRUMENT

	Covariance	Correlation	Probability
Extra-EU import price	12303772	1.00	-
Weighted industrial wages and salaries in non-EU countries	13775.19	0.11	0.19

Source(s): Eurostat, Cambridge Econometrics.

TABLE J.5: RELATIONSHIP BETWEEN THE EXTRA-EU EXPORT PRICE AND ITS INSTRUMENTS

	Covariance	Correlation	Probability
Extra-EU export price	57.71	1.00	-
Wages and salaries	19.86	0.10	0.20
Producer price index	28.60	0.21	0.01
Employment	-632.82	-0.08	0.29

Note(s): Statistics relating to the producer price index exclude Portugal from the sample analysed owing to an absence of data at all levels of NACE detail.
Source(s): Eurostat, Cambridge Econometrics.

TABLE J.6: ESTIMATION RESULTS FROM THE DOMESTIC DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	-27.45	7.87	-3.49	0.00
GDP	2.86	0.66	4.31	0.00
Domestic price index	-0.87	0.34	-2.59	0.01
R-squared	0.95			
Adjusted R-squared	0.94			
# instruments	0			

Source(s): Cambridge Econometrics.

Results

For the domestic demand equation, the results of the Hausman test could not reject the null hypothesis of no endogeneity and the final equation was estimated by Ordinary Least Squares (OLS). The coefficient on import prices was not found to be statistically significant and, as a result, only three terms appear in the final equation: domestic prices, GDP and a constant (see Table J.6). Tests for joint significance of the cross-section and period fixed effects failed to reject the null hypotheses of no joint significance, supporting their inclusion in the final equation. Judged by the R-squared value, the fit of the equation appears good and the estimated value of the price elasticity, between -1 and 0, is in line with our intuition.

The final equation specification settled on for import demand was also estimated by OLS as the Hausman test failed to reject the null hypothesis of no endogeneity. The results show that, as for the domestic equation, both income (the output of principal demand industries) and the own-price variable are significant, but the domestic-price variable was found to be insignificant. Tests for joint significance of the cross-section and period fixed effects failed to reject the null hypotheses of no joint significance, supporting their inclusion in the final equation.

The Hausman test on the final estimated export equation failed to reject the null hypothesis of no endogeneity and the equation was, again, estimated by OLS. Both cross-section and period fixed effects were included in this equation, as supported by the results of the significance tests.

TABLE J.7: ESTIMATION RESULTS FROM THE IMPORT DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	-44.00	19.09	-2.31	0.02
Output of principal demand industries	4.84	1.67	2.90	0.00
Extra-EU import price	-0.53	0.15	-3.54	0.00
R-squared	0.84			
Adjusted R-squared	0.81			
# instruments	0			

Source(s): Cambridge Econometrics.

The variables in the final specification are of the expected sign and significant at the 1% level (see Table J.8). The elasticity of interest, on the extra-EU export price, has a value of -1.81, which is high but plausible. The competing-price variable, the extra-EU import price, was not found to be significant. Various dummy variables were tried but did not lead to any improvement in the results.

TABLE J.8: ESTIMATION RESULTS FROM THE EXPORT DEMAND EQUATION

	Coefficient	Standard deviation	t-Statistic	Probability
Constant	16.94	0.61	27.92	0.00
Extra-EU export price	-1.81	0.29	-6.24	0.00
R-squared	0.86			
Adjusted R-squared	0.83			
# instruments	0			

Source(s): Cambridge Econometrics.

Diagnostic tests

TABLE J.9: UNIT ROOT TEST ON THE RESIDUALS FROM THE DOMESTIC DEMAND EQUATION

	Statistic	Probability	# cross sections	# observations
Levin, Lin & Chu test	-1.95	0.03	12	144

Note(s): The unit root test assumes a common unit root process.
Source(s): Cambridge Econometrics.

TABLE J.10: CORRELOGRAM OF THE RESIDUALS FROM THE DOMESTIC DEMAND EQUATION

	Autocorrelation	Partial correlation	Q-Statistic	Probability
1	0.72	0.72	81.78	0.00
2	0.437	-0.159	112.33	0.00
3	0.152	-0.205	116.05	0.00
4	-0.057	-0.08	116.57	0.00
5	-0.14	0.048	119.79	0.00
6	-0.196	-0.102	126.11	0.00
7	-0.243	-0.137	135.87	0.00
8	-0.302	-0.148	151.06	0.00
9	-0.313	-0.023	167.47	0.00
10	-0.276	-0.022	180.34	0.00
11	-0.185	0.008	186.13	0.00
12	-0.094	-0.05	187.64	0.00

Source(s): Cambridge Econometrics.

Unit root tests were carried out to assess the extent to which the equations suffer from problems of time-series persistence. The null hypothesis is that the residuals from the estimated equations are non-stationary; the alternative is that they are stationary. Table J.9 shows the results of the unit root test carried out on the residuals from the domestic demand equation and indicates that, for this equation and dataset, there is evidence to suggest stationarity in the residuals.

Table J.10 indicates a strong degree of autocorrelation in the residuals from the domestic demand equation and thus evidence of serial correlation. This is perhaps to be expected given that panel data have been used and the equation specification contains no dynamics. There is, however, no impact on the point estimates obtained because the White Heteroskedasticity robust estimator has been used throughout the econometric analysis. The residuals from the trade equations exhibit similar properties to those from the domestic demand equation.

Conclusions

The parameter estimates obtained for this sector are, in general, in line with economic theory and are significant. The domestic demand and import equation show that (macro) income drivers are more important than price and, moreover, we do not find significant coefficients for the cross-price elasticities. Overall, the general levels of fit are high.

Appendix K: Criteria Ranking

Table K.1 shows the calculated measures for the five criteria selected above. The five columns on the right show the same metrics but normalised for a range of 0 to 100, so that the weighting system can be more easily applied. The normalisation system needs to allow for negative figures (for example for negative growth). The method used is to take the difference between the largest and smallest figures and then locate each value on this range. The lowest normalised value will therefore be 0, and the greatest 100.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS

		{ Calculated				}	{ Normalised Values (0-100)				}
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
1010	Mining and agglomeration of hard coal	30	53.4	-5.92	1.86	0.51	42.7	29.3	0.0	12.3	0.0223
1020	Mining and agglomeration of lignite	30	0.9	8.90	0.00		42.7	0.5	41.9	11.4	0.0000
1030	Extraction and agglomeration of peat	5	10		0.00		7.0	5.5	16.7	11.4	0.0000
1110	Extraction of crude petroleum and natural gas	0.8	60.2	27.09	0.00		1.0	33.1	93.3	11.4	0.0000
1120	Service activities incidental to oil and gas extraction excluding surveying	5	5	13.37	0.00		7.0	2.7	54.6	11.4	0.0000
1200	Mining of uranium and thorium ores	5	5		0.00		7.0	2.7	16.7	11.4	0.0000
1310	Mining of uranium and thorium ores	5	84.9		25.10	0.06	7.0	46.6	16.7	23.7	0.0026
1320	Mining of non-ferrous metal ores, except uranium and thorium ores	1.8	86.2	29.45	-7.08	0.23	2.4	47.4	100.0	8.0	0.0103
1411	Quarrying of ornamental and building stone	2	44.2		0.16	0.04	2.7	24.3	16.7	11.5	0.0017
1412	Quarrying of limestone, gypsum and chalk	30	4.4	7.43	18.55	0.01	42.7	2.4	37.7	20.5	0.0005
1413	Quarrying of slate	5	6.4	13.17	-0.12	0.13	7.0	3.5	54.0	11.4	0.0059
1421	Operation of gravel and sand pits	5	3.7		-0.60	0.01	7.0	2.0	16.7	11.1	0.0003
1422	Mining of clays and kaolin	3.3	49	16.20	-3.85	0.02	4.6	26.9	62.6	9.5	0.0008
1430	Mining of chemical and fertilizer minerals	30	61.1	-2.69	5.20	0.03	42.7	33.6	9.1	14.0	0.0015
1440	Production of salt	5	12.5	0.38	2.19	0.04	7.0	6.9	17.8	12.5	0.0018
1450	Other mining and quarrying n.e.c.	3.6	182	4.46	-7.54	0.05	5.0	100.0	29.4	7.7	0.0020
1511	Production and preserving of meat	0.9	11.1		5.47	1.77	1.1	6.1	16.7	14.1	0.0779
1512	Production and preserving of poultrymeat	1.2	6.3		2.65	1.90	1.6	3.5	16.7	12.7	0.0839
1513	Production of meat and poultrymeat products	0.7	3.3		2.28	3.38	0.9	1.8	16.7	12.5	0.1491
1520	Processing and preserving of fish and fish products	1.2	49.7		6.28	4.15	1.6	27.3	16.7	14.5	0.1833

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

NACE code	Sector Title	{ Calculated				}	{ Normalised Values (0-100)				}
		EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
1531	Processing and preserving of potatoes	1.2	5.9	11.67	5.61	1.09	1.6	3.2	49.7	14.2	0.0481
1532	Manufacture of fruit and vegetable juice	1.2	19	2.93	3.77	0.68	1.6	10.4	25.0	13.3	0.0301
1533	Processing and preserving of fruit and vegetables n.e.c.	1	21.6	9.36	2.27	1.11	1.3	11.9	43.2	12.5	0.0492
1541	Manufacture of crude oils and fats	2.7	49.4	2.14	10.99	0.35	3.7	27.1	22.8	16.8	0.0155
1542	Manufacture of refined oils and fats	2.4	19.4	3.86	4.61	0.82	3.3	10.7	27.6	13.7	0.0360
1543	Manufacture of margarine and similar edible fats	0.8	7.8	8.54	-0.72	1.29	1.0	4.3	40.9	11.1	0.0570
1551	Operation of dairies and cheese making	1.3	7.6	2.48	1.85	1.07	1.7	4.2	23.7	12.3	0.0473
1552	Manufacture of ice cream	5	2.8	7.99	1.71		7.0	1.5	39.3	12.3	0.0000
1561	Manufacture of grain mill products	1.3	7.9	5.63	2.35	0.36	1.7	4.3	32.6	12.6	0.0161
1562	Manufacture of starches and starch products	7.1	14.5	6.46	2.77	0.42	10.0	8.0	35.0	12.8	0.0187
1571	Manufacture of prepared feeds for farm animals	1.5	2.8	2.42	2.08	0.25	2.0	1.5	23.6	12.4	0.0109
1572	Manufacture of prepared pet foods	0.6	9.9	7.32	3.66	0.92	0.7	5.4	37.4	13.2	0.0404
1581	Manufacture of bread and fresh pastry goods and cakes	0.4	0.9	9.54	6.94	1.92	0.4	0.5	43.7	14.8	0.0848
1582	Manufacture of rusks and biscuits, preserved pastry goods and cakes	5	6.1	7.06	0.52	2.94	7.0	3.4	36.7	11.7	0.1297
1583	Manufacture of sugar	5.4	19.5		-6.23	0.40	7.6	10.7	16.7	8.4	0.0176
1584	Manufacture of cocoa; chocolate and sugar confectionery	0.6	12.5	12.36	3.05	3.73	0.7	6.9	51.7	12.9	0.1646
1585	Manufacture of macaroni, noodles, couscous and similar farinaceous products	5	10.6	5.54	2.83	1.29	7.0	5.8	32.4	12.8	0.0569
1586	Processing of tea and coffee	0.5	12.4	15.56	1.50	4.81	0.6	6.8	60.7	12.2	0.2121
1587	Manufacture of condiments and seasonings	5	10	5.22	13.50	2.22	7.0	5.5	31.5	18.0	0.0979
1588	Manufacture of homogenized food preparations and dietetic food	1.2	25.1	12.92	4.03	3.48	1.6	13.8	53.3	13.4	0.1535

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{	Calculated			}	{	Normalised Values (0-100)			}
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
1589	Manufacture of other food products n.e.c.	0.6	22.2		-0.31	2.63	0.7	12.2	16.7	11.3	0.1160
1591	Manufacture of distilled potable alcoholic beverages	0.5	53.6	19.31	181.39		0.6	29.5	71.3	100.0	0.0000
1592	Production of ethyl alcohol from fermented materials	5.7	17	15.42	20.29		8.0	9.3	60.3	21.3	0.0000
1593	Manufacture of wines	5	31.5	5.81	1.09		7.0	17.3	33.2	12.0	0.0000
1594	Manufacture of cider and other fruit wines	5	3.6		6.64		7.0	2.0	16.7	14.7	0.0000
1595	Manufacture of other non-distilled fermented beverages	30	25.4	-0.12	9.28		42.7	14.0	16.4	16.0	0.0000
1596	Manufacture of beer	0.7	7.2	11.05	-4.01	0.02	0.9	4.0	48.0	9.5	0.0008
1597	Manufacture of malt	5.9	30.9	-1.60	-3.36	0.30	8.3	17.0	12.2	9.8	0.0131
1598	Production of mineral waters and soft drinks	0.6	6.3	5.23	13.32		0.7	3.5	31.5	17.9	0.0000
1600	Manufacture of tobacco products	0.3	12		-0.62	8.35	0.3	6.6	16.7	11.1	0.3683
1711	Preparation and spinning of cotton-type fibres	5	40.5		0.00		7.0	22.3	16.7	11.4	0.0000
1712	Preparation and spinning of woollen-type fibres	5	40.5		0.00		7.0	22.3	16.7	11.4	0.0000
1713	Preparation and spinning of worsted-type fibres	5	40.5		0.00		7.0	22.3	16.7	11.4	0.0000
1714	Preparation and spinning of flax-type fibres	5	40.5		0.00		7.0	22.3	16.7	11.4	0.0000
1715	Throwing and preparation of silk, including from noils, and throwing and texturing of synthetic or artificial filament yarns	5	40.5		0.00		7.0	22.3	16.7	11.4	0.0000
1716	Manufacture of sewing threads	5	40.5		0.00		7.0	22.3	16.7	11.4	0.0000
1717	Preparation and spinning of other textile fibres	5	40.5		0.00		7.0	22.3	16.7	11.4	0.0000
1721	Cotton-type weaving	1.2	58.3		0.00		1.6	32.0	16.7	11.4	0.0000
1722	Woollen-type weaving	5	58.3		0.00		7.0	32.0	16.7	11.4	0.0000
1723	Worsted-type weaving	5	58.3		0.00		7.0	32.0	16.7	11.4	0.0000

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{	Calculated			}	{	Normalised Values (0-100)			}
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
1724	Silk-type weaving	5	58.3		0.00		7.0	32.0	16.7	11.4	0.0000
1725	Other textile weaving	5	58.3		0.00		7.0	32.0	16.7	11.4	0.0000
1730	Finishing of textiles	1.4	1.5		0.00	1.99	1.9	0.8	16.7	11.4	0.0879
1740	Manufacture of made-up textile articles, except apparel	0.5	46.7		4.82	8.33	0.6	25.7	16.7	13.8	0.3675
1751	Manufacture of carpets and rugs	0.8	31.2	3.28	-4.25	5.51	1.0	17.1	26.0	9.4	0.2433
1752	Manufacture of cordage, rope, twine and netting	1	34.1	4.75	13.26	2.85	1.3	18.7	30.2	17.9	0.1258
1753	Manufacture of non-wovens and articles made from non-wovens, except apparel	5	30.9	12.78	4.77	2.94	7.0	17.0	52.9	13.8	0.1299
1754	Manufacture of other textiles n.e.c.	0.8	37.4		5.99	3.45	1.0	20.5	16.7	14.4	0.1523
1760	Manufacture of knitted and crocheted fabrics	5	47.7		-10.34	7.41	7.0	26.2	16.7	6.4	0.3271
1771	Manufacture of knitted and crocheted hosiery	5	39.3	6.97	-5.24		7.0	21.6	36.4	8.9	0.0000
1772	Manufacture of knitted and crocheted pullovers, cardigans and similar articles	5	63.9	6.07	-4.98		7.0	35.1	33.9	9.0	0.0000
1810	Manufacture of leather clothes	30	52.1		-8.08		42.7	28.6	16.7	7.5	0.0000
1821	Manufacture of workwear	5	44.7	9.60	5.30		7.0	24.6	43.9	14.0	0.0000
1822	Manufacture of other outerwear	0.2	70.6	7.25	1.59		0.1	38.8	37.2	12.2	0.0000
1823	Manufacture of underwear	5	75.6	5.33	-0.42		7.0	41.5	31.8	11.2	0.0000
1824	Manufacture of other wearing apparel and accessories n.e.c.	0.4	99.4	9.90	-2.59	17.36	0.4	54.6	44.7	10.2	0.7662
1830	Dressing and dyeing of fur; manufacture of articles of fur	0.3	101.9		-7.15		0.3	56.0	16.7	7.9	0.0000
1910	Tanning and dressing of leather	5	47.5		2.99	3.61	7.0	26.1	16.7	12.9	0.1592
1920	Manufacture of luggage, handbags and the like, saddler	0.2	87.5		-1.25	27.36	0.1	48.1	16.7	10.8	1.2076
1930	Manufacture of footwear	0.4	59.7		-3.74		0.4	32.8	16.7	9.6	0.0000

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{	Calculated			}	{	Normalised Values (0-100)			}
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
2010	Sawmilling and planing of wood, impregnation of wood	1.6	30.8		-2.44	0.07	2.1	16.9	16.7	10.2	0.0029
2020	Manufacture of veneer sheets, plywood, laminboard, particle board, fibre board and other panels and boards	3.7	23.8		8.31		5.1	13.1	16.7	15.5	0.0000
2030	Manufacture of builders' carpentry and joinery	5	9		7.52	1.69	7.0	4.9	16.7	15.1	0.0747
2040	Manufacture of wooden containers	5	7.4		3.85	0.85	7.0	4.1	16.7	13.3	0.0377
2051	Manufacture of other products of wood	5	26	8.90	-0.51	2.11	7.0	14.3	41.9	11.2	0.0930
2052	Manufacture of articles of cork, straw and plaiting materials	5	36.5	4.48	-0.08	4.03	7.0	20.1	29.4	11.4	0.1777
2111	Manufacture of pulp	5	46.1	14.40	0.51		7.0	25.3	57.4	11.7	0.0000
2112	Manufacture of paper and paperboard	10.2	25.7	11.50	0.35	0.67	14.4	14.1	49.3	11.6	0.0294
2121	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard	1.7	5.2	4.98	7.12	1.08	2.3	2.9	30.8	14.9	0.0475
2122	Manufacture of household and sanitary goods and of toilet requisites	3.4	12.8	10.59	7.29	1.86	4.7	7.0	46.7	15.0	0.0820
2123	Manufacture of paper stationery	5	9.4	6.80	15.57	1.80	7.0	5.2	36.0	19.0	0.0796
2124	Manufacture of wallpaper	5	38.7		3.85	3.41	7.0	21.3	16.7	13.3	0.1506
2125	Manufacture of other articles of paper and paperboard n.e.c.	0.7	13.6	7.15	13.00	5.23	0.9	7.5	36.9	17.8	0.2309
2211	Publishing of books	5	17.4	14.11	8.61		7.0	9.6	56.6	15.6	0.0000
2212	Publishing of newspapers	5	0.2	9.43	-8.63		7.0	0.1	43.4	7.2	0.0000
2213	Publishing of journals and periodicals	5	2.9	12.20	-0.94		7.0	1.6	51.2	11.0	0.0000
2214	Publishing of sound recordings	5	24.3	10.01	28.49		7.0	13.4	45.0	25.3	0.0000
2215	Other publishing	5	37.2	17.01	0.00		7.0	20.4	64.8	11.4	0.0000
2221	Printing of newspapers	5	3.3	7.25	0.00		7.0	1.8	37.2	11.4	0.0000
2222	Printing n.e.c.	0.5	3.7	8.42	-0.51	2.81	0.6	2.0	40.5	11.2	0.1241

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{ Calculated				}	{ Normalised Values (0-100)				}
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
2223	Bookbinding	5	3.3	8.44	0.00		7.0	1.8	40.6	11.4	0.0000
2224	Pre-press activities (Composition and plate-making in NACE Rev.1)	5	6.4	11.45	0.00		7.0	3.5	49.1	11.4	0.0000
2225	Ancillary activities related to printing (Other activities related to printing in NACE Rev.1)	5	3.3	11.86	0.00		7.0	1.8	50.3	11.4	0.0000
2231	Reproduction of sound recording	5	0	14.32	0.00		7.0	0.0	57.2	11.4	0.0000
2232	Reproduction of video recording	5	0		0.00		7.0	0.0	16.7	11.4	0.0000
2233	Reproduction of computer media	5	0	25.96	0.00		7.0	0.0	90.1	11.4	0.0000
2310	Manufacture of coke oven products	41.4	31		0.00		58.9	17.0	16.7	11.4	0.0000
2320	Manufacture of refined petroleum products	11.7	16.1		0.00		16.5	8.8	16.7	11.4	0.0000
2330	Processing of nuclear fuel	5	44.3		0.00		7.0	24.3	16.7	11.4	0.0000
2411	Manufacture of industrial gases	8.9	4.2	20.38	6.59	0.03	12.6	2.3	74.4	14.6	0.0014
2412	Manufacture of dyes and pigments	3.2	43.1	9.06	2.22	2.41	4.4	23.7	42.4	12.5	0.1064
2413	Manufacture of other inorganic basic chemicals	11.9	31.7	9.96	6.45	0.30	16.8	17.4	44.9	14.6	0.0130
2414	Manufacture of other organic basic chemicals	5.4	46.3	14.14	-1.62	0.96	7.6	25.4	56.7	10.6	0.0422
2415	Manufacture of fertilizers and nitrogen compounds	70.2	27.4	5.79	3.15	0.24	100.0	15.1	33.1	13.0	0.0107
2416	Manufacture of plastics in primary forms	3	27.1	5.69	0.38	1.21	4.1	14.9	32.8	11.6	0.0532
2417	Manufacture of synthetic rubber in primary forms	30	38.1	1.23	-6.05	1.28	42.7	20.9	20.2	8.5	0.0563
2420	Manufacture of pesticides and other agro-chemical products	1.6	41.1		10.06		2.1	22.6	16.7	16.3	0.0000
2430	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	5	20.8		-0.06	1.78	7.0	11.4	16.7	11.4	0.0786
2441	Manufacture of basic pharmaceutical products	1.3	85.8	16.48	0.17	5.86	1.7	47.1	63.3	11.5	0.2587
2442	Manufacture of pharmaceutical preparations	0.3	58.6	17.08	0.00		0.3	32.2	65.0	11.4	0.0000

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{ Calculated }					{ Normalised Values (0-100) }				
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
2451	Manufacture of soap and detergents, cleaning and polishing preparations	5	23.1	12.35	9.04	1.20	7.0	12.7	51.6	15.8	0.0530
2452	Manufacture of perfumes and toilet preparations	5	45.3	10.67	-3.21		7.0	24.9	46.9	9.9	0.0000
2461	Manufacture of explosives	5	15.9	9.60	-10.09	2.42	7.0	8.7	43.9	6.5	0.1070
2462	Manufacture of glues and gelatines	0.9	25.9	10.46	2.29	1.45	1.1	14.2	46.3	12.5	0.0641
2463	Manufacture of essential oils	5	77		1.73	10.28	7.0	42.3	16.7	12.3	0.4538
2464	Manufacture of photographic chemical material	1.4	65.7	5.92	-6.24	1.94	1.9	36.1	33.5	8.4	0.0856
2465	Manufacture of prepared unrecorded media	5	105.1	-2.06	29.32	4.31	7.0	57.7	10.9	25.7	0.1900
2466	Manufacture of other chemical products n.e.c.	1.8	49.6	7.45	15.09	0.77	2.4	27.3	37.8	18.8	0.0340
2470	Manufacture of man-made fibres	4.3	32.8		-5.31	2.39	6.0	18.0	16.7	8.8	0.1054
2511	Manufacture of rubber tyres and tubes	1.4	37.1		-1.37	1.88	1.9	20.4	16.7	10.8	0.0828
2512	Retreading and rebuilding of rubber tyres	5	7.1	6.29	-2.46		7.0	3.9	34.5	10.2	0.0000
2513	Manufacture of other rubber products	0.9	26.5	6.99	37.11	3.80	1.1	14.6	36.5	29.5	0.1677
2521	Manufacture of plastic plates, sheets, tubes and profiles	1.4	20.4		1.71	2.20	1.9	11.2	16.7	12.3	0.0971
2522	Manufacture of plastic packing goods	2	14	4.36	6.66	2.40	2.7	7.7	29.1	14.7	0.1057
2523	Manufacture of builders' ware of plastic	0.6	9.4	7.57	8.77	3.54	0.7	5.2	38.1	15.7	0.1563
2524	Manufacture of other plastic products	0.8	20	6.22	4.46	4.34	1.0	11.0	34.3	13.6	0.1915
2611	Manufacture of flat glass	8	21		2.43	0.54	11.3	11.5	16.7	12.6	0.0236
2612	Shaping and processing of flat glass	5	13.5	5.76	18.09	1.81	7.0	7.4	33.0	20.3	0.0798
2613	Manufacture of hollow glass	7.3	24.3	4.97	-4.41	0.36	10.3	13.4	30.8	9.3	0.0158
2614	Manufacture of glass fibres	3.6	23.4	7.14	6.05	1.71	5.0	12.9	36.9	14.4	0.0755

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{ Calculated }					{ Normalised Values (0-100) }				
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
2615	Manufacture and processing of other glass, including technical glassware	2.4	49.1	9.18	-0.70	1.70	3.3	27.0	42.7	11.1	0.0752
2621	Manufacture of ceramic household and ornamental articles	1.8	57	4.27	-9.69	2.93	2.4	31.3	28.8	6.7	0.1295
2622	Manufacture of ceramic sanitary fixtures	1.4	30.2	12.69	-0.67		1.9	16.6	52.6	11.1	0.0000
2623	Manufacture of ceramic insulators and insulating fittings	2.4	34.5	2.69	3.79	5.08	3.3	19.0	24.3	13.3	0.2242
2624	Manufacture of other technical ceramic products	1.2	54.6	7.07	7.83	10.43	1.6	30.0	36.7	15.2	0.4604
2625	Manufacture of other ceramic products	1.5	49.1	10.04	0.83	0.63	2.0	27.0	45.1	11.8	0.0276
2626	Manufacture of refractory ceramic products	2.8	37.2	6.50	1.02	0.61	3.9	20.4	35.1	11.9	0.0270
2630	Manufacture of ceramic tiles and flags	30	28.6		-1.42		42.7	15.7	16.7	10.7	0.0000
2640	Manufacture of bricks, tiles and construction prod.	9.8	2.7		67.38	0.12	13.8	1.5	16.7	44.3	0.0055
2651	Manufacture of cement	45.5	6.8	20.21	6.29	0.07	64.8	3.7	73.9	14.5	0.0030
2652	Manufacture of lime	65.2	2.6	18.45	2.97	0.07	92.9	1.4	68.9	12.9	0.0031
2653	Manufacture of plaster	30	6.5	18.88	-3.25	0.09	42.7	3.6	70.1	9.8	0.0040
2661	Manufacture of concrete products for construction purposes	5	1.5	6.72	0.75	0.09	7.0	0.8	35.7	11.8	0.0038
2662	Manufacture of plaster products for construction purposes	3.2	5.7	20.58	4.32		4.4	3.1	74.9	13.5	0.0000
2663	Manufacture of ready-mixed concrete	5	0.1	5.65	0.98	0.03	7.0	0.1	32.7	11.9	0.0012
2664	Manufacture of mortars	2.4	2.1	9.60	0.37	0.09	3.3	1.2	43.9	11.6	0.0039
2665	Manufacture of fibre cement	5	7.7	3.41	2.00	0.62	7.0	4.2	26.4	12.4	0.0275
2666	Manufacture of other articles of concrete, plaster and cement	5	17.7	8.11	3.24	0.19	7.0	9.7	39.7	13.0	0.0085
2670	Cutting, shaping and finishing of ornamental and building stone	5	27.6		-3.03	0.26	7.0	15.2	16.7	9.9	0.0116
2681	Production of abrasive products	5	40.5		-1.70	3.52	7.0	22.3	16.7	10.6	0.1555

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{	Calculated			}	{	Normalised Values (0-100)			}
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
2682	Manufacture of other non-metallic mineral products n.e.c.	1.7	17.9	3.82	7.29	0.12	2.3	9.8	27.5	15.0	0.0051
2710	Manufacture of basic iron and steel and of ferro-alloys (including production of non-ECSC ferro-alloys in NACE Rev.1.1)	10.6	32.3		5.80	0.50	15.0	17.7	16.7	14.3	0.0220
2721	Manufacture of cast iron tubes	30	28		3.30	1.27	42.7	15.4	16.7	13.0	0.0558
2722	Manufacture of steel tubes	0.9	45.2	5.41	9.78	1.15	1.1	24.8	32.0	16.2	0.0510
2731	Cold drawing	30	32.7	8.05	-0.52	1.32	42.7	18.0	39.5	11.2	0.0583
2732	Cold rolling of narrow strip	5	19.7	7.82	-10.25	1.01	7.0	10.8	38.9	6.4	0.0446
2733	Cold forming or folding	0.4	4.9	7.65	42.77	0.92	0.4	2.7	38.4	32.3	0.0407
2734	Wire drawing	1.9	21.9	6.16	5.22	0.89	2.6	12.0	34.2	14.0	0.0392
2741	Precious metals production	5	73.9		27.68	2265.79	7.0	40.6	16.7	24.9	100.0000
2742	Aluminium production	14	35.9	4.47	7.19	1.82	19.8	19.7	29.4	14.9	0.0804
2743	Lead, zinc and tin production	7.4	26.8	-2.39	1.62	1.89	10.4	14.7	10.0	12.2	0.0835
2744	Copper production	5.5	34.6	2.68	-4.69	4.22	7.7	19.0	24.3	9.1	0.1862
2745	Other non-ferrous metal production	30	73.8		11.24	13.20	42.7	40.5	16.7	16.9	0.5824
2751	Casting of iron	30	0	2.80	4.18	1.43	42.7	0.0	24.6	13.5	0.0630
2752	Casting of steel	2	0	4.41	20.86	4.58	2.7	0.0	29.2	21.6	0.2022
2753	Casting of light metals	5	0	4.21	2.61	5.75	7.0	0.0	28.6	12.7	0.2537
2754	Casting of other non-ferrous metals	5	0	5.23	12.36	4.86	7.0	0.0	31.5	17.5	0.2144
2811	Manufacture of metal structures and parts of structures	5	8.4	6.70	12.94	1.72	7.0	4.6	35.7	17.7	0.0758
2812	Manufacture of builders' carpentry and joinery of metal	0.2	3.3	8.87	34.34		0.1	1.8	41.8	28.2	0.0000
2821	Manufacture of tanks, reservoirs and containers of metal	5	14.5	4.47	6.68	3.41	7.0	8.0	29.4	14.7	0.1505

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{	Calculated			}	{	Normalised Values (0-100)			}
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
2822	Manufacture of central heating radiators and boilers	5	15.3	7.18	6.00	1.75	7.0	8.4	37.0	14.4	0.0773
2830	Manufacture of steam generators, except central heating hot water boilers	0.8	12.6		9.61	9.48	1.0	6.9	16.7	16.1	0.4184
2840	Forging, pressing, stamping and roll forming of metal; powder metallurgy	0.8	0		0.00	2.19	1.0	0.0	16.7	11.4	0.0966
2851	Treatment and coating of metals	5	0	13.82	0.00		7.0	0.0	55.8	11.4	0.0000
2852	General mechanical engineering	5	0	8.00	0.00	3.50	7.0	0.0	39.4	11.4	0.1543
2861	Manufacture of cutlery	5	64.6	9.12	4.24		7.0	35.5	42.5	13.5	0.0000
2862	Manufacture of tools	0.4	42.5	9.33	24.01	14.36	0.4	23.4	43.1	23.2	0.6336
2863	Manufacture of locks and hinges	5	29.8		9.97	4.96	7.0	16.4	16.7	16.3	0.2189
2871	Manufacture of steel drums and similar containers	5	17.8	5.31	-23.40		7.0	9.8	31.7	0.0	0.0000
2872	Manufacture of light metal packaging	5	11.1	7.20	33.60	1.69	7.0	6.1	37.1	27.8	0.0746
2873	Manufacture of wire products	1	21	8.73	7.26	0.96	1.3	11.5	41.4	15.0	0.0424
2874	Manufacture of fasteners, screw machine products, chain and springs	5	36.2	9.08	14.15	2.95	7.0	19.9	42.4	18.3	0.1301
2875	Manufacture of other fabricated metal products n.e.c.	5	37.1	8.90	10.90	2.90	7.0	20.4	41.9	16.7	0.1282
2911	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	0.6	51	7.30	12.13		0.7	28.0	37.4	17.3	0.0000
2912	Manufacture of pumps and compressors	5	47.4	6.57	16.00		7.0	26.0	35.3	19.2	0.0000
2913	Manufacture of taps and valves	5	47.2	8.40	8.02	13.07	7.0	25.9	40.5	15.3	0.5770
2914	Manufacture of bearings, gears, gearing and driving elements	0.5	39	5.88	14.90	9.10	0.6	21.4	33.4	18.7	0.4018
2921	Manufacture of furnaces and furnace burners	5	56.8	6.70	20.04	10.91	7.0	31.2	35.7	21.2	0.4815
2922	Manufacture of lifting and handling equipment	5	26.6	7.40	10.87	4.53	7.0	14.6	37.7	16.7	0.1999

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{ Calculated }					{ Normalised Values (0-100) }				
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
2923	Manufacture of non-domestic cooling and ventilation equipment	0.2	34.5	6.15	22.12		0.1	19.0	34.1	22.2	0.0000
2924	Manufacture of other general purpose machinery n.e.c.	5	46.4	7.62	12.69	18.26	7.0	25.5	38.3	17.6	0.8057
2931	Manufacture of agricultural tractors	30	31.1		17.30		42.7	17.1	16.7	19.9	0.0000
2932	Manufacture of other agricultural and forestry machinery	5	31.1	10.94	16.97		7.0	17.1	47.7	19.7	0.0000
2941	Manufacture of portable hand held power tools	5	73.4		5.56		7.0	40.3	16.7	14.1	0.0000
2942	Manufacture of other metalworking machine tools	5	48.5	4.26	77.10		7.0	26.6	28.8	49.1	0.0000
2943	Manufacture of other machine tools n.e.c.	5	48.1	-2.40	15.74	18.11	7.0	26.4	9.9	19.1	0.7995
2951	Manufacture of machinery for metallurgy	5	42.1	4.94	-2.47		7.0	23.1	30.7	10.2	0.0000
2952	Manufacture of machinery for mining, quarrying and construction	0.3	63	5.38	6.60	2.20	0.3	34.6	31.9	14.6	0.0969
2953	Manufacture of machinery for food, beverage and tobacco processing	0.2	43.6	6.82	14.64		0.1	24.0	36.0	18.6	0.0000
2954	Manufacture of machinery for textile, apparel and leather production	5	71.7	3.37	40.81	29.79	7.0	39.4	26.2	31.4	1.3149
2955	Manufacture of machinery for paper and paperboard production	5	46.6	1.36	13.67		7.0	25.6	20.6	18.1	0.0000
2956	Manufacture of other special purpose machinery n.e.c.	0.1	48.7	4.84	56.98	6.44	0.0	26.8	30.4	39.2	0.2841
2960	Manufacture of weapons and ammunition	0.5	33.6		-4.31	20.17	0.6	18.5	16.7	9.3	0.8900
2971	Manufacture of electric domestic appliances	5	40.7	3.55	-0.76	11.75	7.0	22.4	26.8	11.1	0.5184
2972	Manufacture of non-electric domestic appliances	5	28.2	-3.44	6.27		7.0	15.5	7.0	14.5	0.0000
3001	Manufacture of office machinery	0.9	87.8	10.00	-3.48		1.1	48.2	45.0	9.7	0.0000
3002	Manufacture of computers and other information processing equipment	0.3	83.5	8.85	15.28		0.3	45.9	41.8	18.9	0.0000

Source(s): Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{	Calculated			}	{	Normalised Values (0-100)			}
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
3110	Manufacture of electric motors, generators and transformers	5	43.5		30.13	4.93	7.0	23.9	16.7	26.1	0.2176
3120	Manufacture of electricity distribution and control apparatus	5	39.3		-3.77		7.0	21.6	16.7	9.6	0.0000
3130	Manufacture of insulated wire and cable	1	32.6		-14.63	3.21	1.3	17.9	16.7	4.3	0.1417
3140	Manufacture of accumulators, primary cells and primary batteries	1.9	54.3		33.12	2.32	2.6	29.8	16.7	27.6	0.1022
3150	Manufacture of lighting equipment and electric lamps	5	41.3		3.43		7.0	22.7	16.7	13.1	0.0000
3161	Manufacture of electrical equipment for engines and vehicles n.e.c.	5	21.2	2.66	-3.75	12.28	7.0	11.6	24.3	9.6	0.5420
3162	Manufacture of other electrical equipment n.e.c.	0.5	44.8	8.20	3.02	7.63	0.6	24.6	39.9	12.9	0.3366
3210	Manufacture of electronic valves and tubes and other electronic components	0.8	81.4		4.63		1.0	44.7	16.7	13.7	0.0000
3220	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	0.2	76.8		-4.49		0.1	42.2	16.7	9.2	0.0000
3230	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods	5	70.5		27.38		7.0	38.7	16.7	24.8	0.0000
3310	Manufacture of medical and surgical equipment and orthopaedic appliances	0.2	72.7		8.19		0.1	39.9	16.7	15.4	0.0000
3320	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	0.2	59.6		5.16	26.56	0.1	32.7	16.7	13.9	1.1723
3330	Manufacture of industrial process control equipment	5	0		0.00		7.0	0.0	16.7	11.4	0.0000

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{	Calculated			}	{	Normalised Values (0-100)			}
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
3320	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	0.2	59.6		5.16	26.56	0.1	32.7	16.7	13.9	1.1723
3330	Manufacture of industrial process control equipment	5	0		0.00		7.0	0.0	16.7	11.4	0.0000
3340	Manufacture of optical instruments, photographic equipment	0.4	66.1		16.24	125.83	0.4	36.3	16.7	19.4	5.5536
3350	Manufacture of watches and clocks	5	107.4		-0.22	0.14	7.0	59.0	16.7	11.3	0.0062
3410	Manufacture of motor vehicles	0.5	28.9		2.42		0.6	15.9	16.7	12.6	0.0000
3420	Manufacture of bodies (coachwork) for motor vehicles, trailers and semi-trailers	0.2	10.3		24.34		0.1	5.7	16.7	23.3	0.0000
3430	Manufacture of parts, accessories for motor vehicles	0.6	24.8		5.16	4.24	0.7	13.6	16.7	13.9	0.1869
3511	Building and repairing of ships	5	69.6	4.00	7.03		7.0	38.2	28.0	14.9	0.0000
3512	Building and repairing of pleasure and sporting boats	0.3	62	8.62	14.35		0.3	34.1	41.1	18.4	0.0000
3520	Manufacture of railway, tramway locomotives, rolling stock	0.3	16.4		8.66	3.58	0.3	9.0	16.7	15.7	0.1581
3530	Manufacture of aircraft and spacecraft	0.3	79.7		3.84	82.11	0.3	43.8	16.7	13.3	3.6241
3541	Manufacture of motorcycles	5	52.7	0.99	4.18		7.0	29.0	19.5	13.5	0.0000
3542	Manufacture of bicycles	5	50.4	7.47	-2.66	1.45	7.0	27.7	37.9	10.1	0.0639
3543	Manufacture of invalid carriages	5	35	9.42	1.15		7.0	19.2	43.4	12.0	0.0000
3550	Manufacture of other transport equipment n.e.c.	5	36.6		16.66		7.0	20.1	16.7	19.6	0.0000

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

TABLE K.1: SELECTED QUANTITATIVE CRITERIA FOR NACE 4 SECTORS (continued)

		{	Calculated			}	{	Normalised Values (0-100)			}
NACE code	Sector Title	EC IA Cost/GVA %	EC IA Trade/Output %	Profits 2004 %	Av. Growth 2004-8 %	Sales/kg 2004 €/kg	EC IA Cost/GVA	EC IA Trade/Output	Profits 2004	Av. Growth 2004-8	Sales/kg 2004
3611	Manufacture of chairs and seats	5	20.4	2.83	4.31		7.0	11.2	24.7	13.5	0.0000
3612	Manufacture of other office and shop furniture	5	10.6	5.13	5.68		7.0	5.8	31.2	14.2	0.0000
3613	Manufacture of other kitchen furniture	5	7.3	-3.51	5.04		7.0	4.0	6.8	13.9	0.0000
3614	Manufacture of other furniture	0.5	28.5	6.79	11.39	3.29	0.6	15.7	35.9	17.0	0.1451
3615	Manufacture of mattresses	5	8.3	-2.63	-5.00		7.0	4.6	9.3	9.0	0.0000
3621	Striking of coins	5	49.4		-4.32	19.77	7.0	27.1	16.7	9.3	0.8728
3622	Manufacture of jewellery and related articles n.e.c.	5	102.6	8.65	3.16	120.72	7.0	56.4	41.2	13.0	5.3278
3630	Manufacture of musical instruments	5	78.2		4.43		7.0	43.0	16.7	13.6	0.0000
3640	Manufacture of sports goods	5	66.6		-3.07		7.0	36.6	16.7	9.9	0.0000
3650	Manufacture of games and toys	0.4	76.1		-3.37	1.71	0.4	41.8	16.7	9.8	0.0756
3661	Manufacture of imitation jewellery	5	88.2	10.83	-14.38	51.35	7.0	48.5	47.4	4.4	2.2665
3662	Manufacture of brooms and brushes	5	43.3	7.80	-0.41		7.0	23.8	38.8	11.2	0.0000
3663	Other manufacturing n.e.c.	1.1	60.4	10.10	11.98	2.11	1.4	33.2	45.3	17.3	0.0931
3710	Recycling of metal waste and scrap	5	0	0.00	0.00		7.0	0.0	16.7	11.4	0.0000
3720	Recycling of non-metal waste and scrap	5	0	0.00	0.00		7.0	0.0	16.7	11.4	0.0000
3611	Manufacture of chairs and seats	5	20.4	2.83	4.31		7.0	11.2	24.7	13.5	0.0000

Source(s) : Entec, SBS, PRODCOM, EC Impact Assessment.

Appendix L: Sensitivity Analysis

Tables L.1 to L.16 show each of the 16 combinations of modelling results for the four scenarios and four sensitivities. The four scenarios are:

- Reference Scenario
- Copenhagen Accord Low Offers
- EU Stretch, Copenhagen Low
- Copenhagen High

The four sensitivities are:

- 80% free allocation of EU ETS permits
- 50% free allocation of EU ETS permits
- Border Adjustment Mechanisms (BAMs)
- electricity price regulation

TABLE L.1: DEMAND IMPACTS OF 50% FREE ALLOCATION IN REFERENCE SCENARIO (%)

	S1 – Reference				S1a – 50% free allocation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-0.8	1.4	0.0	-0.6	-0.6	1.1	0.0	-0.5
Manufacture of other inorganic basic chemicals	-0.8	0.0	-1.9	-0.9	-0.6	0.0	-1.5	-0.7
Manufacture of plastics in primary forms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of glues and gelatines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of flat glass	-1.3	0.0	-0.6	-1.2	-0.8	0.0	-0.4	-0.8
Manufacture of glass fibres	-0.1	0.0	-0.3	-0.2	-0.1	0.0	-0.2	-0.1
Manufacture of ceramic tiles and flags	-7.4	17.0	-32.3	-15.1	-3.9	8.9	-16.9	-7.9
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-5.2	-0.1	0.0	0.0	-3.1	-0.1
Manufacture of lime	-11.9	0.0	-24.8	-12.1	-6.2	0.0	-12.9	-6.3
Manufacture of plaster products for construction purposes	-0.8	0.0	-0.5	-0.8	-0.5	0.0	-0.3	-0.5
Manufacture of basic iron and steel and of ferro-alloys	-12.3	0.4	-8.8	-11.6	-8.3	0.3	-6.0	-7.9
Casting of steel	0.0	0.4	0.0	0.0	0.0	0.4	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-0.9	-0.2	0.0	0.0	-0.5	-0.1
Manufacture of motor vehicles	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.2: DEMAND IMPACTS OF 80% FREE ALLOCATION IN REFERENCE SCENARIO (%)

	S1 – Reference				S1b – 80% free allocation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-0.8	1.4	0.0	-0.6	-0.5	0.9	0.0	-0.4
Manufacture of other inorganic basic chemicals	-0.8	0.0	-1.9	-0.9	-0.5	0.0	-1.3	-0.6
Manufacture of plastics in primary forms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of glues and gelatines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of flat glass	-1.3	0.0	-0.6	-1.2	-0.6	0.0	-0.3	-0.6
Manufacture of glass fibres	-0.1	0.0	-0.3	-0.2	-0.1	0.0	-0.2	-0.1
Manufacture of ceramic tiles and flags	-7.4	17.0	-32.3	-15.1	-2.6	5.9	-11.1	-5.2
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-5.2	-0.1	0.0	0.0	-2.3	0.0
Manufacture of lime	-11.9	0.0	-24.8	-12.1	-4.1	0.0	-8.5	-4.1
Manufacture of plaster products for construction purposes	-0.8	0.0	-0.5	-0.8	-0.4	0.0	-0.3	-0.4
Manufacture of basic iron and steel and of ferro-alloys	-12.3	0.4	-8.8	-11.6	-6.9	0.2	-4.9	-6.5
Casting of steel	0.0	0.4	0.0	0.0	0.0	0.3	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-0.9	-0.2	0.0	0.0	-0.3	-0.1
Manufacture of motor vehicles	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.3: DEMAND IMPACTS OF BORDER ADJUSTMENT MECHANISM IN REFERENCE SCENARIO (%)

	S1 – Reference				S1c – BAMs			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-0.8	1.4	0.0	-0.6	-0.8	1.4	0.0	-0.6
Manufacture of other inorganic basic chemicals	-0.8	0.0	-1.9	-0.9	-0.8	-0.7	-1.9	-0.9
Manufacture of plastics in primary forms	0.0	0.0	0.0	0.0	0.3	-0.2	0.0	0.2
Manufacture of glues and gelatines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of flat glass	-1.3	0.0	-0.6	-1.2	-1.3	-1.4	-0.6	-1.2
Manufacture of glass fibres	-0.1	0.0	-0.3	-0.2	-0.1	0.0	-0.3	-0.2
Manufacture of ceramic tiles and flags	-7.4	17.0	-32.3	-15.1	-5.5	14.7	-32.3	-13.8
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-5.2	-0.1	0.0	0.0	-5.2	-0.1
Manufacture of lime	-11.9	0.0	-24.8	-12.1	-11.9	-7.3	-24.8	-12.1
Manufacture of plaster products for construction purposes	-0.8	0.0	-0.5	-0.8	-0.8	-0.9	-0.5	-0.8
Manufacture of basic iron and steel and of ferro-alloys	-12.3	0.4	-8.8	-11.6	-12.3	-0.6	-8.8	-11.6
Casting of steel	0.0	0.4	0.0	0.0	0.0	-0.8	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-0.9	-0.2	0.0	0.0	-0.9	-0.2
Manufacture of motor vehicles	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.4: DEMAND IMPACTS OF ELECTRICITY REGULATION IN REFERENCE SCENARIO (%)

	S1 – Reference				S1d – non EU electricity price regulation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-0.8	1.4	0.0	-0.6	-0.8	1.4	0.0	-0.6
Manufacture of other inorganic basic chemicals	-0.8	0.0	-1.9	-0.9	-0.8	-0.7	-1.9	-0.9
Manufacture of plastics in primary forms	0.0	0.0	0.0	0.0	0.3	-0.2	0.0	0.2
Manufacture of glues and gelatines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of flat glass	-1.3	0.0	-0.6	-1.2	-1.3	-1.4	-0.6	-1.2
Manufacture of glass fibres	-0.1	0.0	-0.3	-0.2	-0.1	0.0	-0.3	-0.2
Manufacture of ceramic tiles and flags	-7.4	17.0	-32.3	-15.1	-5.5	14.7	-32.3	-13.8
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-5.2	-0.1	0.0	0.0	-5.2	-0.1
Manufacture of lime	-11.9	0.0	-24.8	-12.1	-11.9	-7.3	-24.8	-12.1
Manufacture of plaster products for construction purposes	-0.8	0.0	-0.5	-0.8	-0.8	-0.9	-0.5	-0.8
Manufacture of basic iron and steel and of ferro-alloys	-12.3	0.4	-8.8	-11.6	-12.3	-0.6	-8.8	-11.6
Casting of steel	0.0	0.4	0.0	0.0	0.0	-0.8	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-0.9	-0.2	0.0	0.0	-0.9	-0.2
Manufacture of motor vehicles	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.5: DEMAND IMPACTS OF 50% FREE ALLOCATION IN COPENHAGEN LOW SCENARIO (%)

	S2 –Copenhagen Low				S2a – 50% free allocation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-0.8	1.4	0.0	-0.6	-0.6	1.1	0.0	-0.5
Manufacture of other inorganic basic chemicals	-0.8	-0.2	-1.9	-0.9	-0.6	-0.2	-1.5	-0.7
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.1	-0.1	0.1	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.3	-0.5	-0.4	-1.2	-0.8	-0.5	-0.2	-0.7
Manufacture of glass fibres	-0.1	0.0	-0.2	-0.1	-0.1	0.0	-0.1	-0.1
Manufacture of ceramic tiles and flags	-7.2	16.8	-32.3	-14.9	-3.7	8.6	-16.9	-7.8
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-5.2	-0.1	0.0	0.0	-3.1	-0.1
Manufacture of lime	-11.9	-3.5	-24.8	-12.1	-6.2	-3.5	-12.9	-6.3
Manufacture of plaster products for construction purposes	-0.8	-0.4	-0.4	-0.7	-0.5	-0.4	-0.2	-0.5
Manufacture of basic iron and steel and of ferro-alloys	-12.3	0.2	-8.2	-11.5	-8.3	0.1	-5.3	-7.8
Casting of steel	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-0.9	-0.2	0.0	0.0	-0.5	-0.1
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.6: DEMAND IMPACTS OF 80% FREE ALLOCATION IN COPENHAGEN LOW SCENARIO (%)

	S2 – EU Stretch, Copenhagen Low				S2a – 50% free allocation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-0.8	1.4	0.0	-0.6	-0.5	0.9	0.0	-0.4
Manufacture of other inorganic basic chemicals	-0.8	-0.2	-1.9	-0.9	-0.5	-0.2	-1.3	-0.6
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.1	-0.1	0.1	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.3	-0.5	-0.4	-1.2	-0.6	-0.5	-0.1	-0.6
Manufacture of glass fibres	-0.1	0.0	-0.2	-0.1	-0.1	0.0	-0.1	-0.1
Manufacture of ceramic tiles and flags	-7.2	16.8	-32.3	-14.9	-2.3	5.6	-11.1	-5.1
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-5.2	-0.1	0.0	0.0	-2.3	0.0
Manufacture of lime	-11.9	-3.5	-24.8	-12.1	-4.1	-3.5	-8.5	-4.1
Manufacture of plaster products for construction purposes	-0.8	-0.4	-0.4	-0.7	-0.4	-0.4	-0.1	-0.4
Manufacture of basic iron and steel and of ferro-alloys	-12.3	0.2	-8.2	-11.5	-6.9	0.0	-4.3	-6.4
Casting of steel	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-0.9	-0.2	0.0	0.0	-0.3	-0.1
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.7: DEMAND IMPACTS OF BORDER ADJUSTMENT MECHANISM IN COPENHAGEN LOW SCENARIO (%)

	S2 –Copenhagen Low				S2c – BAMs			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-0.8	1.4	0.0	-0.6	-0.8	1.4	0.0	-0.6
Manufacture of other inorganic basic chemicals	-0.8	-0.2	-1.9	-0.9	-0.8	-0.7	-1.9	-0.9
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.3	-0.2	0.1	0.2
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.3	-0.5	-0.4	-1.2	-1.3	-1.4	-0.4	-1.2
Manufacture of glass fibres	-0.1	0.0	-0.2	-0.1	-0.1	0.0	-0.2	-0.1
Manufacture of ceramic tiles and flags	-7.2	16.8	-32.3	-14.9	-5.5	14.7	-32.3	-13.8
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-5.2	-0.1	0.0	0.0	-5.2	-0.1
Manufacture of lime	-11.9	-3.5	-24.8	-12.1	-11.9	-7.3	-24.8	-12.1
Manufacture of plaster products for construction purposes	-0.8	-0.4	-0.4	-0.7	-0.8	-0.9	-0.4	-0.7
Manufacture of basic iron and steel and of ferro-alloys	-12.3	0.2	-8.2	-11.5	-12.3	-0.6	-8.2	-11.5
Casting of steel	0.0	0.2	0.0	0.0	0.0	-0.8	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-0.9	-0.2	0.0	0.0	-0.9	-0.2
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.8: DEMAND IMPACTS OF ELECTRICITY REGULATION IN COPENHAGEN LOW SCENARIO (%)

	S2 –Copenhagen Low				S2d – non-EU electricity price regulation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-0.8	1.4	0.0	-0.6	-0.8	1.4	0.0	-0.6
Manufacture of other inorganic basic chemicals	-0.8	-0.2	-1.9	-0.9	-0.8	-0.1	-1.9	-0.9
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.1	0.0	0.0	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Manufacture of flat glass	-1.3	-0.5	-0.4	-1.2	-1.3	-0.3	-0.5	-1.2
Manufacture of glass fibres	-0.1	0.0	-0.2	-0.1	-0.1	0.0	-0.3	-0.1
Manufacture of ceramic tiles and flags	-7.2	16.8	-32.3	-14.9	-7.2	16.8	-32.3	-15.0
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-5.2	-0.1	0.0	0.0	-5.2	-0.1
Manufacture of lime	-11.9	-3.5	-24.8	-12.1	-11.9	-3.5	-24.8	-12.1
Manufacture of plaster products for construction purposes	-0.8	-0.4	-0.4	-0.7	-0.8	-0.4	-0.4	-0.8
Manufacture of basic iron and steel and of ferro-alloys	-12.3	0.2	-8.2	-11.5	-12.3	0.2	-8.4	-11.6
Casting of steel	0.0	0.2	0.0	0.0	0.0	0.4	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-0.9	-0.2	0.0	0.0	-0.9	-0.2
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.9: DEMAND IMPACTS OF 50% FREE ALLOCATION IN EU STRETCH COPENHAGEN LOW SCENARIO (%)

	S3 – EU Stretch, Copenhagen Low				S3a – 50% free allocation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-0.8	1.4	0.0	-0.6
Manufacture of other inorganic basic chemicals	-1.0	-0.2	-2.6	-1.2	-0.8	-0.2	-2.0	-0.9
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.1	-0.1	0.1	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.7	-0.5	-0.6	-1.6	-1.1	-0.5	-0.3	-1.0
Manufacture of glass fibres	-0.2	0.0	-0.3	-0.2	-0.2	0.0	-0.2	-0.2
Manufacture of ceramic tiles and flags	-9.6	22.4	-43.1	-20.0	-4.9	11.6	-22.6	-10.4
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-4.1	-0.1
Manufacture of lime	-15.9	-3.5	-33.0	-16.1	-8.3	-3.5	-17.2	-8.4
Manufacture of plaster products for construction purposes	-1.0	-0.4	-0.5	-1.0	-0.6	-0.4	-0.3	-0.6
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.3	-11.1	-15.4	-11.1	0.2	-7.3	-10.4
Casting of steel	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-0.6	-0.1
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.10: DEMAND IMPACTS OF 80% FREE ALLOCATION IN EU STRETCH COPENHAGEN LOW SCENARIO (%)

	S3 – EU Stretch, Copenhagen Low				S3b – 80% free allocation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-0.7	1.2	0.0	-0.5
Manufacture of other inorganic basic chemicals	-1.0	-0.2	-2.6	-1.2	-0.7	-0.2	-1.8	-0.8
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.1	-0.1	0.1	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.7	-0.5	-0.6	-1.6	-0.8	-0.5	-0.2	-0.8
Manufacture of glass fibres	-0.2	0.0	-0.3	-0.2	-0.2	0.0	-0.2	-0.2
Manufacture of ceramic tiles and flags	-9.6	22.4	-43.1	-20.0	-3.2	7.6	-14.9	-6.8
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-3.0	-0.1
Manufacture of lime	-15.9	-3.5	-33.0	-16.1	-5.4	-3.5	-11.3	-5.5
Manufacture of plaster products for construction purposes	-1.0	-0.4	-0.5	-1.0	-0.5	-0.4	-0.2	-0.5
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.3	-11.1	-15.4	-9.1	0.1	-5.9	-8.5
Casting of steel	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-0.4	-0.1
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.11: DEMAND IMPACTS OF BORDER ADJUSTMENT MECHANISM IN EU STRETCH COPENHAGEN LOW SCENARIO (%)

	S3 – EU Stretch, Copenhagen Low				S3c –BAMs			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-1.0	1.9	0.0	-0.8
Manufacture of other inorganic basic chemicals	-1.0	-0.2	-2.6	-1.2	-1.0	-0.9	-2.6	-1.2
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.3	-0.3	0.1	0.3
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.7	-0.5	-0.6	-1.6	-1.7	-1.9	-0.6	-1.6
Manufacture of glass fibres	-0.2	0.0	-0.3	-0.2	-0.2	0.0	-0.3	-0.2
Manufacture of ceramic tiles and flags	-9.6	22.4	-43.1	-20.0	-7.4	19.6	-43.1	-18.4
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-6.9	-0.1
Manufacture of lime	-15.9	-3.5	-33.0	-16.1	-15.9	-9.7	-33.0	-16.1
Manufacture of plaster products for construction purposes	-1.0	-0.4	-0.5	-1.0	-1.0	-1.1	-0.5	-1.0
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.3	-11.1	-15.4	-16.4	-0.8	-11.1	-15.4
Casting of steel	0.0	0.3	0.0	0.0	0.0	-1.0	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-1.2	-0.3
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.12: DEMAND IMPACTS OF ELECTRICITY REGULATION IN EU STRETCH COPENHAGEN LOW SCENARIO (%)

	S3 – EU Stretch, Copenhagen Low				S3d – non-EU electricity price regulation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-1.0	1.9	0.0	-0.8
Manufacture of other inorganic basic chemicals	-1.0	-0.2	-2.6	-1.2	-1.0	-0.1	-2.6	-1.2
Manufacture of plastics in primary forms	0.1	-0.1	0.1	0.1	0.1	0.0	0.0	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Manufacture of flat glass	-1.7	-0.5	-0.6	-1.6	-1.7	-0.3	-0.7	-1.6
Manufacture of glass fibres	-0.2	0.0	-0.3	-0.2	-0.2	0.0	-0.3	-0.2
Manufacture of ceramic tiles and flags	-9.6	22.4	-43.1	-20.0	-9.7	22.5	-43.1	-20.0
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-6.9	-0.1
Manufacture of lime	-15.9	-3.5	-33.0	-16.1	-15.9	-3.5	-33.0	-16.1
Manufacture of plaster products for construction purposes	-1.0	-0.4	-0.5	-1.0	-1.0	-0.4	-0.6	-1.0
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.3	-11.1	-15.4	-16.4	0.4	-11.3	-15.4
Casting of steel	0.0	0.3	0.0	0.0	0.0	0.5	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-1.2	-0.3
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.13: DEMAND IMPACTS OF 50% FREE ALLOCATION IN COPENHAGEN HIGH SCENARIO (%)

	S4 –Copenhagen High				S1a – 50% free allocation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-0.8	1.4	0.0	-0.6
Manufacture of other inorganic basic chemicals	-1.0	-0.3	-2.6	-1.2	-0.8	-0.3	-2.0	-0.9
Manufacture of plastics in primary forms	0.2	-0.1	0.1	0.1	0.2	-0.1	0.1	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.7	-0.6	-0.6	-1.6	-1.1	-0.6	-0.3	-1.0
Manufacture of glass fibres	-0.2	0.0	-0.2	-0.2	-0.2	0.0	-0.2	-0.2
Manufacture of ceramic tiles and flags	-9.4	22.1	-43.1	-19.8	-4.7	11.3	-22.6	-10.2
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-4.1	-0.1
Manufacture of lime	-15.9	-5.4	-33.0	-16.1	-8.3	-5.4	-17.2	-8.4
Manufacture of plaster products for construction purposes	-1.0	-0.6	-0.5	-1.0	-0.6	-0.6	-0.2	-0.6
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.2	-10.6	-15.3	-11.1	0.0	-6.8	-10.3
Casting of steel	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-0.6	-0.1
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.14: DEMAND IMPACTS OF 80% FREE ALLOCATION IN COPENHAGEN HIGH SCENARIO (%)

	S4 – Copenhagen High				S4b – 80% free allocation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-0.7	1.2	0.0	-0.5
Manufacture of other inorganic basic chemicals	-1.0	-0.3	-2.6	-1.2	-0.7	-0.3	-1.8	-0.8
Manufacture of plastics in primary forms	0.2	-0.1	0.1	0.1	0.2	-0.1	0.1	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.7	-0.6	-0.6	-1.6	-0.8	-0.6	-0.2	-0.8
Manufacture of glass fibres	-0.2	0.0	-0.2	-0.2	-0.2	0.0	-0.2	-0.2
Manufacture of ceramic tiles and flags	-9.4	22.1	-43.1	-19.8	-2.9	7.2	-14.9	-6.6
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-3.0	-0.1
Manufacture of lime	-15.9	-5.4	-33.0	-16.1	-5.4	-5.4	-11.3	-5.5
Manufacture of plaster products for construction purposes	-1.0	-0.6	-0.5	-1.0	-0.5	-0.6	-0.1	-0.5
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.2	-10.6	-15.3	-9.1	0.0	-5.4	-8.4
Casting of steel	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-0.4	-0.1
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.15: DEMAND IMPACTS OF BORDER ADJUSTMENT MECHANISM IN COPENHAGEN HIGH SCENARIO (%)

	S4 –Copenhagen High				S4c - BAMs			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-1.0	1.9	0.0	-0.8
Manufacture of other inorganic basic chemicals	-1.0	-0.3	-2.6	-1.2	-1.0	-0.9	-2.6	-1.2
Manufacture of plastics in primary forms	0.2	-0.1	0.1	0.1	0.3	-0.3	0.1	0.3
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Manufacture of flat glass	-1.7	-0.6	-0.6	-1.6	-1.7	-1.9	-0.6	-1.6
Manufacture of glass fibres	-0.2	0.0	-0.2	-0.2	-0.2	0.0	-0.2	-0.2
Manufacture of ceramic tiles and flags	-9.4	22.1	-43.1	-19.8	-7.4	19.6	-43.1	-18.4
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-6.9	-0.1
Manufacture of lime	-15.9	-5.4	-33.0	-16.1	-15.9	-9.7	-33.0	-16.1
Manufacture of plaster products for construction purposes	-1.0	-0.6	-0.5	-1.0	-1.0	-1.1	-0.5	-1.0
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.2	-10.6	-15.3	-16.4	-0.8	-10.6	-15.3
Casting of steel	0.0	0.0	0.0	0.0	0.0	-1.0	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-1.2	-0.3
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source(s) : Cambridge Econometrics.

TABLE L.16: DEMAND IMPACTS OF ELECTRICITY REGULATION IN COPENHAGEN HIGH SCENARIO (%)

	S4 –Copenhagen High				S4d – non-EU electricity price regulation			
	Domestic	Import	Export	EU production	Domestic	Import	Export	EU production
Manufacture of paper and paperboard	-1.0	1.9	0.0	-0.8	-1.0	1.9	0.0	-0.8
Manufacture of other inorganic basic chemicals	-1.0	-0.3	-2.6	-1.2	-1.0	-0.2	-2.6	-1.2
Manufacture of plastics in primary forms	0.2	-0.1	0.1	0.1	0.1	-0.1	0.1	0.1
Manufacture of glues and gelatines	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Manufacture of flat glass	-1.7	-0.6	-0.6	-1.6	-1.7	-0.4	-0.6	-1.6
Manufacture of glass fibres	-0.2	0.0	-0.2	-0.2	-0.2	0.0	-0.3	-0.2
Manufacture of ceramic tiles and flags	-9.4	22.1	-43.1	-19.8	-9.4	22.2	-43.1	-19.8
Manufacture of bricks, tiles and construction products, in baked clay	0.0	0.0	-6.9	-0.1	0.0	0.0	-6.9	-0.1
Manufacture of lime	-15.9	-5.4	-33.0	-16.1	-15.9	-5.3	-33.0	-16.1
Manufacture of plaster products for construction purposes	-1.0	-0.6	-0.5	-1.0	-1.0	-0.5	-0.5	-1.0
Manufacture of basic iron and steel and of ferro-alloys	-16.4	0.2	-10.6	-15.3	-16.4	0.3	-11.0	-15.4
Casting of steel	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
Manufacture of agricultural tractors	0.0	0.0	-1.2	-0.3	0.0	0.0	-1.2	-0.3
Manufacture of motor vehicles	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0

Source(s) : Cambridge Econometrics.