11 Structural Change and Competitiveness

Key Messages

The costs of mitigation will not be felt uniformly across countries and sectors. Greenhouse-gas-intensive sectors, and countries, will require the most structural adjustment, and the timing of action by different countries will affect the balance of costs and benefits.

If some countries move more quickly than others in implementing carbon reduction policies, there are concerns that carbon-intensive industries will locate in countries without such policies in place. A relatively small number of carbon-intensive industries could suffer significant impacts as an inevitable consequence of properly pricing the cost of greenhouse-gas (GHG) emissions.

The empirical evidence on trade and location decisions, however, suggests that only a small number of the worst affected sectors have internationally mobile plant and processes. Moreover, to the extent that these firms are open to competition this tends to come predominately from countries within regional trading blocs. This suggests that action at this regional level will contain the competitiveness impact.

Trade diversion and relocation are less likely, the stronger the expectation of eventual global action as firms take long-term decisions when investing in plant and equipment that will produce for decades.

International sectoral agreements for GHG-intensive industries could play an important role in promoting international action for keeping down competitiveness impacts for individual countries.

Even where industries are internationally mobile, environmental policies are only one determinant of plant and production location decisions. Other factors such as the quality of the capital stock and workforce, access to technologies, infrastructure and proximity to markets are usually more important determinants of industrial location and trade than pollution restrictions.

11.1 Introduction

All economies undergo continuous structural change through time. Indeed, the most successful economies are those that have the flexibility and dynamism to cope with and embrace change. Action to address climate change will require policies that deter greenhouse gas emitting activities, and stimulate a further phase of structural change.

One concern is that under different speeds of action, policies might be disproportionately costly to countries or companies that act faster, as they might lose energy-intensive production and exports to those who act more slowly. This could lead to relocation that simply transfers, rather than reduces, global emissions, making the costs borne by more active countries self-defeating.

Even where action is taken on a more uniform collective basis, concern remains that different countries will be affected differently. Some countries have developed comparative advantages in GHG-intensive sectors and would be hit hardest by attempts to rein-in emissions and shift activity away from such production.

The “competitiveness” of a firm or country is defined in terms of relative performance. An uncompetitive firm risks losing market share and going out of business. On the other hand, a country cannot “close”, but low competitiveness means the economy is likely to grow more slowly with lower real wage growth and enjoy fewer opportunities than more competitive economies. At the national level, promoting competitiveness means applying policies and re-vamping institutions to enable the economy to adapt more flexibly to new markets and opportunities, and facilitate the changes needed to raise productivity. Carefully designed, flexible policies to encourage GHG mitigation and stimulate innovation need not be inconsistent with enhancing national competitiveness. On the contrary, the innovation associated with tackling climate change could trigger a new wave of growth and creativity in the global economy. It is up to individuals, countries, governments and companies to tailor their policies and actions to seize the opportunities.

Section 11.2 looks at the likely distribution of carbon costs across industrial sectors and assesses their exposure to international competition. Section 11.3 examines evidence behind firms' location decisions and the degree to which environmental regulations influence trade patterns. Climate change policies may also help meet other goals, such as enhanced energy security, reduced local pollution and energy market reform and these issues are addressed in detail in the next chapter.

11.2 Distribution of costs and implications for competitiveness

To assess the likely impact of carbon costing, a disaggregated assessment of fossil fuel inputs into various production processes is required. For many countries, this can be by analysing whole economy disaggregated Input-Output tables. Using the UK as a detailed case study, direct and indirect carbon costs can be applied to various fossil fuel inputs, and traced through the production process, to final goods prices (see Box 11.1). This reveals the carbon intensity of production. It also gives a crude estimate of the final impact on total consumer prices, and so reflects the reduction in consumer purchasing power[1].

The impacts of action to tackle climate change are unevenly distributed between sectors

Input-Output tables can be used to look at the distribution of carbon costs across sectors of the economy. For illustrative purposes, the UK, with energy intensity close to the OECD average, is used as a case study of disaggregated cost impacts. However, the lessons drawn for the UK need not be applicable to all countries, even within the OECD.

An illustrative carbon price of £70/tC ($30/t$CO_2$)[2] can be traced through the economy's disaggregated production process, to final consumer prices. Adding the carbon price raises the cost of fossil fuel energy in proportion to carbon intensity of each fossil fuel input (oil, gas and coal) see Box 11.1.

The overall impact is to raise consumer prices by just over one per cent on the assumption of a full cost pass-through. However, the impact on costs and prices in the most carbon-intensive industries, either directly or indirectly through, say, their consumption of electricity, is considerably higher. In the UK, six industries out of 123 would face an increase in variable costs of 5% or more as a result of the impact of carbon pricing on higher energy costs (see table 11A.1 at end). In these industries prices would have to rise by the following amounts for profits to remain unchanged:

- gas supply and distribution (25%);
- refined petroleum (24%);
- electricity production and distribution (16%);
- cement (9%);
- fertilisers (5%);

[1] This assumes no behavioural response and no substitution opportunities and 100% pass through of costs. It is in theory possible to use older full supply-use Input-Output tables and the inverse Leontief matrix to gauge the rough magnitude of higher order indirect impacts. The study has not done this, but extending the analysis to include more multipliers shows the numbers converging to zero quite quickly, suggesting this analysis offers a close approximation.
[2] This figure is illustrative, but the impact on prices is linear so the results can be appropriately factored up/down drawn for different carbon costs. Ideally this figure should correspond with the social cost of carbon (see Chapter 13), which to put it into context, is slightly above prices quoted in the European Emissions Trading scheme – ETS – over the much of the past year. It is important to distinguish tonnes of carbon from carbon dioxide as the two measures are used interchangeably. £1/tC = £0.273/tCO_2 so £70/tC = £19/tCO_2. Exchange rates are calculated at 2003 purchasing power parities.

- fishing (5%)

Although this analysis is restricted to the UK, it is these same industries, together with metals, chemicals, paper/pulp, and transport that dominate global carbon emissions from fossil fuels the world over. The competitiveness impacts in these sectors will be reduced to the extent that they are not highly traded. In the UK, combined export and import intensity for these sectors is below 50% (see Box 11.3)[3].

Box 11.1 Potential costs to firms and consumers; UK Input-Output study

The primary users of fossil fuels (oil, gas and coal) as direct inputs include refined petrol, electricity, gas distribution, the fossil fuel extraction industries and fertiliser production. Figure A shows the share of oil & gas and coal in variable cost for these primary users.

Input-Output analysis can trace the impact of carbon pricing on secondary users of oil, gas and coal - defined as those industries that use inputs from the primary oil, gas and coal users such as electricity. Outputs from these sectors are then fed in as inputs to other sectors, and so on. For illustrative purposes, Figure B shows the impact of a carbon price of £70/tC, but the effects are linear with respect to price and so different impacts for different prices can be assessed using the appropriate multiple. Chapter 9 showed that although the average abatement cost may fall as new technologies arise, the marginal abatement cost is likely to rise with time, reflecting the rising social cost of carbon as the atmospheric carbon stock increases. As industry becomes decarbonised, the whole-economy impact is likely to begin to fall. But going the other way will be the rising social cost of carbon and the corresponding marginal abatement cost (this is illustrated in Box 9.6). This will have an increasing impact on costs in remaining carbon-intensive sectors.

Figure A Share of oil & gas and coal extraction in variable costs, percent

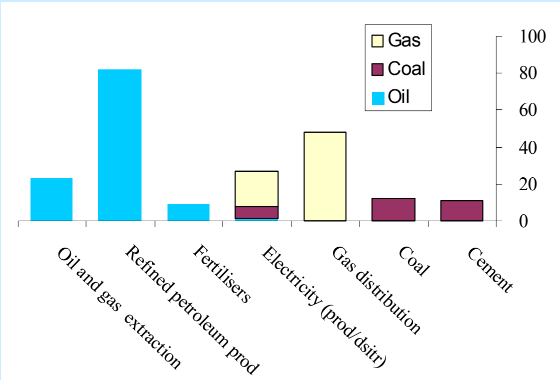
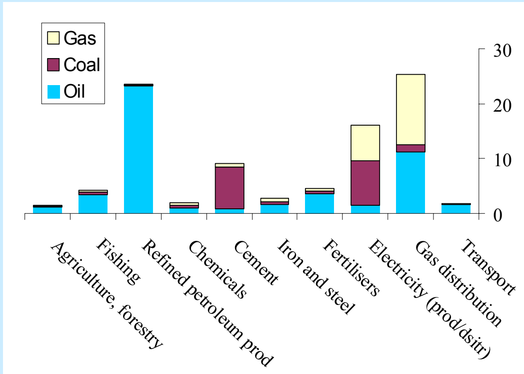


Figure B Product price increases from £70/tC pricing (full pass-through), percent



The largest users of petroleum-products include agriculture, forestry and fishing, chemicals and the transportation sectors. The main users of coal are electricity and cement. The main users of electricity include the electricity sector itself, a number of manufacturing industries and the utilities supplying gas and water.

Total fossil fuel energy costs account for 3% of variable costs in UK production. When the illustrative carbon price of £70/tC ($30/tCO$_2$) is applied, whole economy production costs might be expected to rise by just over 1%. Only 19 out of 123 sectors, accounting for less than 5% of total UK output, would see variable costs increase of more than 2% and only six would undergo an increase of 5% or more[4].

Mapping costs through to final consumer goods prices, the aggregate impact on consumer prices of a £70/tC would be of the order of a 1.0% one-off increase in costs, with oil's contribution accounting for just under half and the remainder split between gas and coal[5].

[3] Trade intensity defined as total and exports of goods and services as a percentage of total supply of goods and services, plus imports of goods and services as a percentage of total demand for goods and services. Output is defined as gross, so the maximum value attainable is 200.
[4] Full industry listings for all 123 Standard Industrial Classification (SIC) sectors are given in annex table 11A.1.
[5] It is in theory possible to use older full supply-use Input-Output tables and the inverse Leontief matrix to gauge the

Electricity and gas distribution for example are almost entirely domestic, and to the extent energy intensive industries do trade, this is mostly within the EU. Trade intensity falls by a factor of two to seven for the key energy-intensive industries when measured in terms of non-EU trade only. See Annex table 11A.1 for details of trade intensity among carbon-intensive activities. Nevertheless:

- The magnitude of the impact on a small number of sectors is such that it could provide incentives for import substitution and incentives to relocate to countries with more relaxed mitigation regimes, even though these sectors are not currently characterised by high trade intensity. Further, many industries suffering smaller price increases are more open to trade: these include oil and gas extraction or air transport. The competitiveness impacts will be reduced if climate change action is coordinated globally.

- It is likely that some sectors (for example steel and cement or even electricity for a more inter-connected country) may be more vulnerable in countries bordering more relaxed mitigation regimes. Such countries should conduct similar Input-Output exercises to assess the vulnerability of their tradable sectors.

- In addition, there is a problem of aggregation. Aluminium smelting for example is among the most heavily energy-intensive industrial processes. Yet the upstream process is classed under broader 'non-ferrous metals' (of which aluminium accounts for around half). Hence although it is correct to conclude that overall value-added is not at much as risk, to infer that aluminium production is not at risk would be wrong. In general, upstream metal production tends to be both the most energy-intensive and tradable component, something that analysis at broad level of aggregation may not reveal.

The forgoing analysis offers an indication of the distribution of static costs among various sectors from pricing-in the cost of GHG emissions. However, there is a risk that action to reduce GHG emissions could generate dynamic costs, for example, scrapping capital prematurely and de-skilling workers might retard the economy's ability to grow. Before assessing these costs, it is important to re-emphasise that under 'business as usual' policies, dynamic costs relating to early capital scrapping and adjustment are liable to be even larger in the medium term. Timely investment will reduce the impact of climate change. Chapter 8 showed that a smooth transition to a low GHG environment with early action to reduce emissions is likely to limit adjustment costs.

The dynamic impacts from a transition to a low-GHG economy should be small. The change in relative prices that is likely to result from adopting the social cost of carbon into production activities is well within the 'normal' range of variation in prices experienced in an open economy. Input cost variations from recent fluctuations in the exchange rate and the world oil price, for example, are likely to far exceed the short-run primary energy cost increases from a carbon tax required to reflect the damage from emissions (see Box 11.2).

rough magnitude of this higher order indirect impact. Because data disaggregated to a level commodity output per unit of domestically met final demand has not been published in the UK since 1993, the study has not adopted this approach and has not been able to follow the impact through the entire supply-chain. However, extending the analysis to include more multipliers seems to make little difference to the results, suggesting the numbers presented here are a close approximation to the price impacts that would be derived using an up-to-date inverse Leontief.

Box 11.2 Vulnerability to energy shocks: lessons from oil and gas prices

Past energy price movements can be used to illustrate the likely economic impact of carbon pricing. Energy costs constitute a small part of total gross output costs, in most developed economies under 5%, in contrast to, say, labour costs, which account for up to a third of total gross output costs. Nevertheless, past movements in energy costs can offer a guide to the potential impact of carbon proving.

UK I-O tables show that oil and gas together account for more than ninety percent of UK fossil fuel energy consumption, but only three-quarters of fossil fuel emissions, as coal is more carbon-intensive. The I-O data reveal that a £10/tC ($4/t$CO_2$) carbon price would have a similar impact on producer prices as a $1.6/bl rise in oil prices *with a proportionate gas price increase*.

To put this in context, the sterling oil price has risen 240% in real terms from its level over most of the period 1986-1997($18/bl) to around $69/bl (as of May 2006), and by 150% in real terms since 2003 (average), when the price of Brent crude hovered at around $26/bl for most of the year. On this basis, the change in the real oil price since 2003, assuming a proportionate changes in gas prices, is likely to have had a similar impact on the economy as unchanged oil and gas prices and the imposition of a £260/tC ($132/t$CO_2$) carbon price[6]. Or, alternatively, a £70/tC ($30/t$CO_2$) carbon resource cost is likely to have a similar impact as a $11/bl real oil price increase (at 2003 prices), according to I-O tables.

Gross estimate of impact on UK consumer prices and GDP*

	Brent spot price $ per barrel (real)	Equivalent Carbon cost £/T carbon	Equivalent Carbon cost $/T CO2	Consumer prices, % change	GDP % change (prod'r prices)
2003 average,	26.3	0	0	0.0	0.0
	38	70	30	0.9	-1.2
	40	84	37	1.1	-1.5
	60	206	90	2.6	-3.6
	80	329	143	4.2	-5.7
	100	451	196	5.8	-7.9

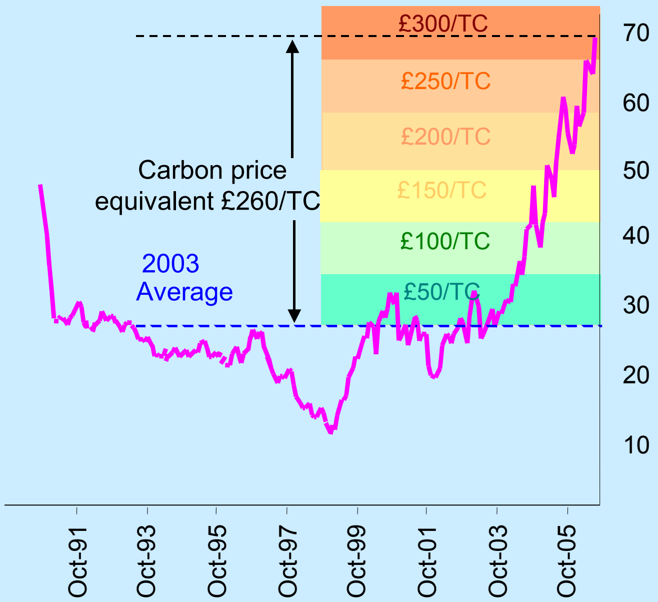
*Uses 2003 prices and Input-output tables; assumes no substitution in producer processes or consumption patterns and assumes all revenues are lost to economy.
Source: Stern using 2003 UK Input-Output tables, Carbon Trust carbon intensity and UK DTI energy price statistics.

In practice, the overall impact on GDP from oil and gas price rises is likely to have been far smaller than suggested here at the national and global level. This is because the rise in the oil price in part reflects a transfer of rent to low marginal cost oil exporters, who in turn will spend more on imported goods and services from oil-importers. The presence of rent in the oil price means the impact on GDP is likely to be over-estimated even for oil importers. Furthermore, to the extent that carbon taxes generate transfers within the economy, the impact on GDP will also be exaggerated. Finally, the use of fixed Input-Output tables assume consumer and producer behaviour is static.

In practice, costs will be lowered as firms and consumers switch out of more expensive carbon-intensive activities. Consequently, the total impact of both carbon pricing and oil price changes on GDP will be lower than the numbers presented here, which should be regarded as an illustrative upper-end estimate of the costs of mitigation in the energy sector for applying any given carbon price.

[6] The exercise assumes that gas prices change in full proportion with oil prices, but that coal prices remain unchanged. In reality oil and gas prices tend to co-move as they are partial substitutes within a fossil fuel energy market and are linked contractually.

The recent rise in the Brent spot price, US $ per barrel (2003 prices)



Source: Ecowin, Stern

The economic literature investigating the impact of energy cost changes focuses disproportionately on resource, capital and energy-intensive sectors and firms. While this is understandable from a policy perspective, since regulation is likely to disproportionately affect these sectors, it also indicates a significant gap in data on other sectors in particular services, which constitute up to three quarters of some developed economies output.

The analysis also assumes that carbon costs are fully passed through to final prices. In practice this need not be the case, especially for tradable sectors that face sensitive demand and are likely to "price-to-markets" to avoid a loss of market share. In addition, the presence of competing inputs, and the opportunity to change processes and reduce emissions, also serve to limit the impact on both profits and prices. However, this analysis still gives an indication of which sectors are most vulnerable to a profit squeeze if carbon pricing is applied to emissions.

The nature of the policy instrument and the framework under which it is applied will also lead to sectoral distributions of costs. For example:

- Who bears the costs/gains from emissions trading depends on whether the allowances are auctioned or given out for free.
- The scope of trading schemes also matters. The EU ETS, for example, extends to primary carbon-intensive sectors, but does not allocate permits to secondary users, such as the aluminium sector, which relies heavily on electricity inputs[7].
- The structure of the electricity market also helps determine outcomes. In highly regulated or nationalised electricity markets, for example, carbon costs are not necessarily passed through, in which case the impact would be felt through the public finances. With regulation limiting cost pass-through in a private sector industry, there will be a squeeze on profits with impacts felt by shareholders. Different impacts will be felt across the globe, but the analysis here gives an indication of the sectors likely to be directly affected.

[7] For analysis of the structure and impact of the EU ETS see: Frontier Economics (2006); Carbon Trust (2004); Grubb (2004); Neuhoff (2006); Sijm et al. (2005) OXERA (2004) and Reinaud (2004).

International sectoral agreements for such industries could play an important role in both promoting international action and keeping down competitiveness impacts for individual countries. Chapter 22 shows how emissions intensities within sectors often vary greatly across the world, so a focus on transferring and deploying technology through sectoral approaches could reduce intensities relatively quickly. Global coverage of particular sectors that are internationally exposed to competition and produce relatively homogenous products can reduce the impact of mitigation policy on competitiveness. A sectoral approach may also make it easier to fund the gap between technologies in developed and developing countries.

Countries most reliant on energy-intensive goods and services may be hardest hit.

The question of the distribution of additional costs applies to countries also. Some small agricultural or commodity-based economies rely heavily on long-distance transport to deliver products to markets while some newly-industrialising countries are particularly energy-intensive. Primary energy consumption as a percent of GDP is generally three or four times higher in the developing world than in the OECD[8], though in rapidly growing sectors and countries such as China and India, primary energy consumption per unit output has fallen sharply as new efficient infrastructure is installed (see Section 7.3). Some of these countries may benefit from energy efficiency improvements and energy market reforms that could lower real costs, but the distribution of costs raises issues relating to design of policies and different speeds of action required to help with the transition in certain countries and sectors (see Part VI).

The impact on oil and fossil fuel producers will depend on the future energy market and the rate of economic diversification in the relevant economies during the transition, which will open up new opportunities for exploiting and exporting renewable energy and new technologies such as carbon capture and storage. Producers of less carbon-intensive fossil fuels, such as gas, will tend to benefit relative to coal or lignite producers.

Where transfers are involved, the extra burden on rich countries need not be significant given the disparities in global income. For illustration, assume GHG stabilisation requires a commitment of 1% of world GDP annually to tackle climate change. If, in the initial decades, the richest 20% of the world's population, which produce 80% of the world's output and income, agreed to pay 20% more - or 1.2% of GDP, this would allow the poorer 80% of the worlds population to shoulder costs equivalent to only 0.2% of GDP[9]. Similarly, transfers to compensate countries facing disproportionately large and costly adjustments to the structure of their economies could also be borne at relatively small cost, if distributed evenly at a global level. Questions of how the costs of mitigation should be borne internationally are discussed in Part VI of this report.

11.3 Carbon mitigation policies and industrial location

The impact on industrial location if countries move at different speeds is likely to be limited

The transitional costs associated with implementing GHG reduction policies faster in one country than in another were outlined in the previous section. In the long run, however, (when by definition, resources are fully employed and the impact for any single country is limited to the relocation of production and employment between industries), openness to trade allows for cheap imports to substitute domestic production in polluting sectors subject to GHG pricing. This is likely to reduce the long-run costs of GHG mitigation to consumers, while some domestic GHG-intensive firms that are relatively open to trade lose market share.

[8] International Energy Agency (2005).

[9] OECD economies account for 15% of the world's population and just over 75% of world output in terms of GDP at current prices using World Bank Statistics (2004). Use of market prices overstates the real value of output in rich countries relative to poorer countries because equivalent non-tradable output in general tends to be cheaper in poorer countries. However, in terms of ability to transfer income globally at market exchange rates, market prices are the appropriate measure.

A reduction in GHG-intensive activities is the ultimate goal of policies designed to reduce emissions. However, this aim is most efficiently achieved in an environment of global collective action (see Part VI). This is because if some countries move faster than others, the possible relocation of firms to areas with weaker GHG policies could reduce output in countries implementing active climate change policies by more than the desired amount (that is, the amount that would prevail in the case where *all* countries adopted efficient GHG policies). At the same time, global emissions would fall by less than the desired amount if polluters simply re-locate to jurisdictions with less active climate change policies[10].

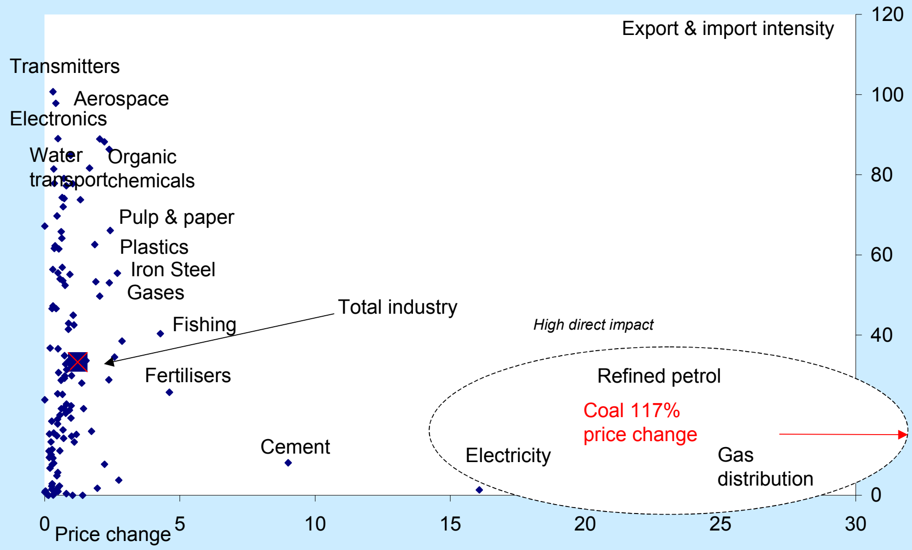
This risk should not be exaggerated. To the extent that energy-intensive industry is open to trade, the bulk of this tends to be limited to within regional trading blocks. UK Input-Output tables, for example, suggest trade diversion is likely to be reduced where action is taken at an EU level (see Box 11.3). However, several sectors are open to trade outside the EU. To the extent that variations in the climate change policy regime between countries result in trade diversion in these sectors the impact on GHG emissions will be reduced.

Box 11.3 The risk of trade diversion and firm relocation – a UK Input-Output case-study

By changing relative prices, GHG abatement will reduce demand for GHG-intensive products. Sectors open to competition from countries not enforcing abatement policies will not be able to pass on costs to consumers without risking market share. The short-run response to such elastic demand is likely to be lower profits. In the long run, with capital being mobile, firms are likely to make location decisions on the basis of changing comparative advantages.

I-O analysis helps identify which industries are likely to suffer trade diversion and consider relocation: in general the list is short. Continuing with the £70/tC ($30/tCO_2$) carbon price example, the figure below maps likely output price changes against exposure to foreign trade[11]. With the exception of refined petrol and coal, fuel costs are not particularly exposed to foreign trade. Under carbon pricing, the price of electricity and gas distribution is set to rise by more than 15%, but output is destined almost exclusively for domestic markets. In all other cases, price increases are limited to below - mostly well below - 10%.

Vulnerable industries: price sensitivity and trade exposure, percent



The bulk of the economy is not vulnerable to foreign competition as a result of energy price rises. However, a few sectors are. Apart from refined petrol, these include fishing, coal, paper

[10] The 'desired amount' refers to the amount consistent with relative comparative advantages in an 'ideal' world with collective action, where gains form trade are maximised.

[11] This is defined as exports of goods and services as a percentage of total supply of goods and services, plus imports of goods and services as a percentage of total demand for goods and services. Output is defined as gross, so the maximum value attainable is 200.

and pulp, iron and steel, fertilisers, air and water transport, chemicals, plastics, fibres and non-ferrous metals, of which aluminium accounts for approximately half of value added. In addition, the level of aggregation used in I-O analysis masks the likelihood that certain processes and facilities within sectors will be both highly energy-intensive and exposed to global competition.

The impact on competitiveness will depend not only on the strength of international competition in the markets concerned, but also the geographical origin of that competition. Many of the proposed carbon abatement measures (such as the EU ETS) are likely to take place at an EU level and energy-intensive sectors tend to trade very little outside the EU.

Trade intensity falls seven-fold in the cement industry when restricted to non-EU countries, as cement is bulky and hard to transport over long distances. Trade in fresh agricultural produce drops by a factor of 5 when restricted only to non-EU countries. The next largest drop in trade occurs in pulp and paper, plastics and fibres. Here trade intensity is quartered at the non-EU level. Trade intensity in plastics and iron and steel and land-transport as well as fishing and fertilisers drop by two-thirds. Trade intensity for air transport and refinery products halves in line with the average for all sectors (complete non-EU trade intensities are listed in Annex table 11A.1). All of these sectors are fossil fuel-intensive; suggesting that restrictions applied at the EU level would greatly diminish the competitiveness impact of carbon restrictions.

Trade diversion and relocation are also less likely, the stronger the expectation of eventual global action. Firms need to take long-term decisions when investing in plant and equipment intended for decades of production. One illustration of this effect is the growing aluminium sector in Iceland. Iceland has attracted aluminium producers from Europe and the US partly because a far greater reliance on renewable electricity generation has reduced its exposure to prices increases, as a result of the move to GHG regulations (see Box 11.4).

Box 11.4 Aluminium production in Iceland

Over the last six years, Iceland has become the largest producer of primary aluminium in the world on a per capita basis. The growth in aluminium production is the result both of expansion of an existing smelter originally built in 1969 and construction of a new green-field smelter owned by an American concern and operated since 1998. The near-future looks set to see a continuing sharp increase in aluminium production in Iceland. Both existing plants have plans for large expansions in the near future. These projects are forecast to boost aluminium production in Iceland to about one million tonnes a year, making Iceland the largest aluminium producer in western Europe.

Power-intensive operations like aluminium smelters are run by large and relatively footloose international companies. Iceland has access to both the European and US aluminium market, but its main advantage is the availability of water and emission-free, renewable energy. Emissions of CO_2 from electricity production per capita in Iceland is the lowest in the OECD: 70% of its primary energy consumption is met by domestic, sustainable energy resources. Iceland is also taking action to reduce emissions of fluorinated compounds associated with aluminium smelting. Expectations of future globalisation action to mitigate GHG emissions is already acting as a key driver in attracting investment of energy-intensive sectors away from high GHG energy suppliers and towards countries with renewable energy sources.

The impact on location and trade is likely to be more substantial for mitigating countries bordering large trade-partners with more relaxed regimes, such as Canada which borders the US, and Spain which is close to North Africa. For example, Canada's most important trading partner, the United States, has not signed the Kyoto Protocol, raising concerns of a negative competitive impact on Canada's energy-intensive industry.[12] However, even for open markets such as Canada and the US, or states within the EU, firms tend to be reluctant to relocate or

[12] For an interesting discussions see the Canadian Government's *Industry Canada* (2002) report, as well as the representations of the Canadian Plastic Industry Association.

trade across borders, when they have markets in the home nation. This so-called "home-bias" effect is surprisingly powerful and the consequent necessity for firms to locate within borders to access local markets limits the degree to which they are footloose in their ability to relocate when faced with carbon pricing[13].

Theory suggests that country-specific factors, such as the size and quality of the capital stock and workforce, access to technologies and infrastructure, proximity to large consumer markets and trading partners, and other factor endowments are likely to be the most important determinants of location and trade. In addition, the business tax and regulatory environment, agglomeration economies, employment law and sunk capital costs are also key determinants. These factors are unlikely to be much affected by GHG mitigation policies. Overall, empirical evidence supports the theory, and suggests environmental policies do affect pollution-intensive trade and production on the margin, but there is little evidence of major relocations[14] [15].

Environmental policies are only one determinant of plant and production location decisions. Costs imposed by tighter pollution regulation are not a major determinant of trade and location patterns, even for those sectors most likely to be affected by such regulation.

The bulk of the world's polluting industries remain located in OECD countries despite tighter emissions standards[16]. By the same token, 2003 UK Input-Output tables show that around 75% of UK trade in the output of carbon-intensive industries is with EU countries with broadly similar environmental standards, with little tendency for such products to be imported from less stringent environmental jurisdictions.

One way of assessing the impact of environmental regulations is to see if greater trade openness has led to a relocation of polluting industries to poorer countries, which have not tightened environmental standards. Antweiler, Copeland and Taylor (2001) calculated country-specific elasticities of pollution concentrations with respect to an increase in openness over the latter part of the twentieth century (Figure 11.1). A positive value for a country implies that trade liberalisation shifts pollution-intensive production towards that country, in effect signalling that it has a comparative advantage in such production.

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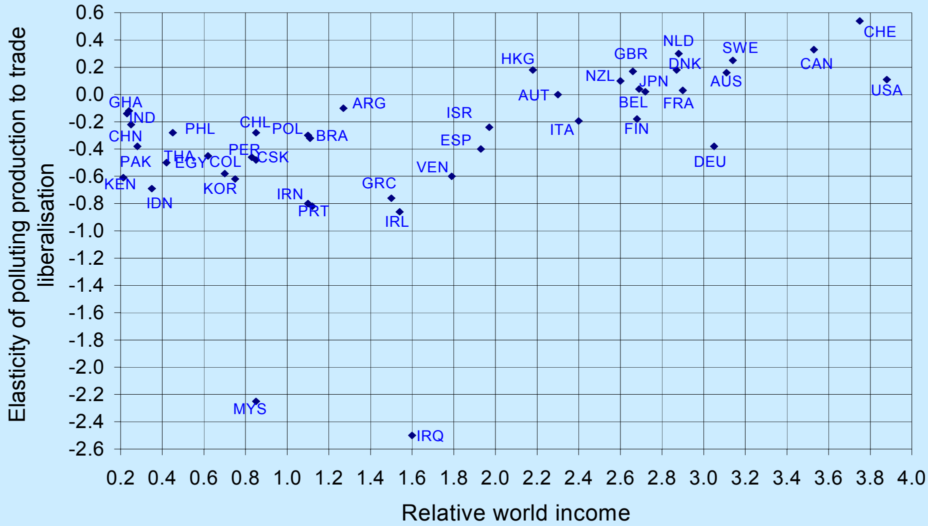
[13] This was the finding of McCallum's seminal 1995 paper, further reinforced by subsequent discussions such as Helliwell's assessment of Canadian-US economic relations, and Berger and Nitsch's (2005) gravity model of intra-EU trade, both of which found significant evidence of home-bias where borders inhibit trade despite open markets and short distances.

[14] See Copeland and Taylor (2004) for one of the most thorough-going theoretical and empirical investigation into environmental regulations and location decisions. See also Levinson et al (2003), Smita et al. (2004) Greenstone (2002), Cole et al. (2003), Ederington et al (2000, 2003), Jeppesen (2002), Xing et al. (2002), UNDP (2005).

[15] The analysis by Smita et al. (2004) confirms that other factors are likely to be more significant determinants of international location and direct investment decisions - factors such as the availability of infrastructure, agglomeration economies and access to large consumer markets. The study of the influence of air pollution regulations carried out by AEA Metroeconomica found that "it is extremely difficult to assess the impact of air pollution on relocation from the other factors that determine location decisions."

[16] Low and Yeats (1992) reported that over 90% of all 'dirty-good' production in 1988 was in OECD countries. This fact alone suggests the location of dirty-good production across the globe reflects much more than weak environmental regulations. See also Trefler (1993) and Mani et al (1997).

Figure 11.1 Trade liberalisation reveals 'comparative advantages' in pollution



Source: Anweiler etal.

Perhaps surprisingly, the study found that rich countries have tended to have unexploited comparative advantages in pollution-intensive production and tend to have positive values for the elasticity while poorer countries tend to have negative values. This indicates that opening up trade will on average shift polluting production towards richer countries. The authors offer this as support for the view that factor endowments such as capital intensity, availability of technology and skilled labour, and access to markets and technologies are the key determinants of environmentally sensitive firms' location decisions. Such factors outweigh rich countries' tendency to apply tighter environmental restrictions in determining firms' location decisions.

11.4 Conclusion

The competitiveness threat arising if some countries move quicker than others in mitigating GHGs is, for most countries, not a macro-economic one, but certain processes and facilities could be exposed in the transition to a low-emissions environment, with new plant diverted to countries or regions with less active climate change policies.

However, if early and gradual action is taken regionally, such impacts are likely to apply to only a very narrow subset of production in a few states with little impact on the economy as a whole. There is likely to be a differentiation in a country's attractiveness as an investment location towards less carbon-intensive activities, but with well-designed policies and flexible institutions there will also be new opportunities in innovative sectors.

Environmental policies are only one determinant of plant and production location decisions. Even for those sectors most likely to be affected by such regulation, factors such as the quality of the capital stock and workforce, access to technologies and infrastructure and the efficiency of the tax and regulation system are more significant. Proximity to markets and suppliers is another important determinant of location and trade. These fundamental factors will always be the key drivers of overall national competitiveness and dynamic economic performance.

Focusing on the costs of mitigation is not the whole story: there are a number of non-climate change related benefits that countries which take action to mitigate GHGs will benefit from; these are outlined in the next chapter.

References

General discussions defining competitiveness are few and far between, reflecting the fact that the definition varies depending on the context. An entertaining account of the problems associated with defining "competitiveness" and the limitations to the notion when applied at a national level can be found in Krugman (1994) and at a more applied level in Azar (2005). There are a number of very thorough and well-researched sectoral analyses of the competitiveness impact of climate change policies; particularly informative are Demailly and Quirion's (2006) study of competitiveness in the European cement industry and Berman and Bui's account of location decisions in the fossil fuel price sensitive refinery sector. There are also a host of in-depth studies of specific regional policies, in particular the competitiveness impact of the EU ETS. Among the many notable reports listed below are: Frontier Economics (2006); Oxera (2006); Grubb Neuhoff (2006), and Reinaud (2004).

Perhaps the most authoritative and comprehensive account of the evolving literature on firms' location decisions in the presence of differential national environmental policies can be found in Copeland and Taylor (2004). Smita et al. (2004) and Lowe and Yeats also undertake in-depth analyses of the degree to which environmental regulations influence trade patters. McCallum (1995) and Nitsch and Berger (2005) provide illustrations of the impact of country borders in containing trade, even where borders are open and goods are highly tradable.

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Annex table 11A.1 Key statistics for 123 UK production sectors (ranked by carbon intensity).[17]

	Carbon intensity (ppt change at £70/tC)	Energy % total costs	Export and import intensity*	Export and import intensity* Non-EU	Percent total UK output
Metal ores extraction	0.00	0.00	67.17	62.86	0.00
Private households with employed persc	0.00	0.00	0.78	0.33	0.50
Financial intermediation services indire	0.00	0.00	23.82	10.75	-4.68
Letting of dwellings	0.03	0.07	1.10	0.47	7.90
Owning and dealing in real estate	0.08	0.23	0.35	0.20	1.89
Estate agent activities	0.11	0.29	0.11	0.06	0.50
Membership organisations nec	0.14	0.37	0.00	0.00	0.59
Legal activities	0.16	0.43	11.04	6.58	1.39
Market research, management consulta	0.17	0.46	9.44	5.58	1.15
Architectural activities and technical con	0.17	0.47	15.31	8.98	1.95
Accountancy services	0.20	0.53	6.77	3.96	0.99
Other business services	0.20	0.55	36.76	21.98	3.53
Computer services	0.23	0.60	13.32	5.76	2.93
Insurance and pension funds	0.24	0.67	10.15	8.10	2.36
Other service activities	0.25	0.68	2.28	1.16	0.64
Recreational services	0.26	0.64	18.47	10.64	2.87
Health and veterinary services	0.26	0.59	1.49	0.63	4.99
Advertising	0.27	0.72	11.46	6.53	0.67
Footwear	0.27	0.60	46.59	21.14	0.03
Banking and finance	0.27	0.78	7.66	4.56	4.05
Education	0.28	0.68	2.88	1.57	6.01
Auxiliary financial services	0.30	0.73	56.36	35.31	0.88
Transmitters for TV, radio and phone	0.30	0.64	100.70	24.66	0.14
Telecommunications	0.31	0.82	9.28	4.27	2.29
Receivers for TV and radio	0.31	0.63	47.26	24.36	0.08
Social work activities	0.31	0.84	0.03	0.02	1.80
Construction	0.32	0.77	0.23	0.09	6.20
Office machinery & computers	0.33	0.69	81.43	31.86	0.24
Tobacco products	0.33	0.84	15.53	8.03	0.12
Ancillary transport services	0.33	0.97	8.03	3.94	1.81
Medical and precision instruments	0.35	0.80	61.60	33.79	0.56
Pharmaceuticals	0.36	0.77	77.84	31.70	0.64
Leather goods	0.38	0.82	62.28	34.31	0.02
Aircraft and spacecraft	0.41	0.90	97.80	64.35	0.54
Research and development	0.42	1.10	46.57	27.48	0.42
Motor vehicle distribution and repair, aut	0.43	1.22	1.04	0.48	2.24
Renting of machinery etc	0.45	1.25	4.87	2.48	1.07
Printing and publishing	0.45	0.90	14.87	7.02	1.64
Jewellery and related products	0.45	0.89	69.70	54.02	0.04
Retail distribution	0.47	1.26	1.68	0.70	5.73
Confectionery	0.47	0.80	17.80	4.48	0.22
Other transport equipment	0.47	1.10	25.34	12.58	0.10
Hotels, catering, pubs etc	0.48	1.26	19.02	8.38	3.32
Postal and courier services	0.48	1.37	5.69	2.71	0.86
Electronic components	0.49	0.89	88.97	40.31	0.13
Electrical equipment nec	0.49	1.10	55.50	24.19	0.21
Wearing apparel and fur products	0.49	1.02	36.55	22.00	0.17
Public administration and defence	0.49	1.31	0.96	0.58	5.12
Soap and toilet preparations	0.51	1.15	30.60	8.91	0.20
Motor vehicles	0.52	1.10	61.50	14.54	0.85
Sewage and sanitary services	0.54	1.47	2.33	1.15	0.67
Railway transport	0.56	1.40	11.11	4.67	0.29
Made-up textiles	0.56	1.30	20.02	12.84	0.07
Cutlery, tools etc	0.56	1.27	54.00	22.75	0.15
Other food products	0.61	1.47	28.70	7.94	0.26
Electric motors and generators etc	0.61	1.42	65.78	32.83	0.23
Furniture	0.62	1.48	21.64	8.29	0.37
Agricultural machinery	0.63	1.48	64.12	19.21	0.05
Machine tools	0.64	1.40	74.32	33.24	0.07
General purpose machinery	0.65	1.56	56.89	22.56	0.40
Weapons and ammunition	0.65	1.31	25.19	14.51	0.06
Insulated wire and cable	0.67	1.37	53.54	24.58	0.04
Soft drinks and mineral waters	0.67	1.44	16.32	3.93	0.10
Special purpose machinery	0.68	1.59	72.01	35.36	0.27

…/(continued) key statistics for 123 production sectors.

[17] by 123 industry Standard Industrial Classification (SIC) level

	Carbon intensity (ppt change at £70/tC)	Energy % total costs	Export and import intensity*	Export and import intensity* Non-EU	Percent total UK output
Meat processing	0.70	1.80	21.72	4.83	0.34
Bread, biscuits etc	0.70	1.60	14.22	2.72	0.32
Mechanical power equipment	0.71	1.51	79.07	41.72	0.26
Knitted goods	0.72	1.48	74.07	40.57	0.04
Domestic appliances nec	0.73	1.76	34.84	13.75	0.11
Alcoholic beverages	0.73	1.71	29.24	13.36	0.29
Paints, varnishes, printing ink etc	0.74	1.67	29.78	8.75	0.12
Rubber products	0.76	1.70	52.40	17.45	0.16
Wood and wood products	0.77	1.95	32.75	10.07	0.28
Sports goods and toys	0.78	1.94	20.48	12.46	0.05
Water supply	0.80	1.56	0.42	0.21	0.30
Pesticides	0.80	1.83	77.22	30.00	0.05
Grain milling and starch	0.81	2.01	22.74	5.38	0.10
Metal boilers and radiators	0.81	1.78	31.36	7.21	0.07
Wholesale distribution	0.82	2.48	-	-	4.41
Textile fibres	0.87	1.68	41.41	18.12	0.03
Other metal products	0.88	2.03	42.92	18.03	0.24
Plastic products	0.90	1.99	33.69	11.10	0.63
Dairy products	0.91	2.56	21.26	3.66	0.14
Other textiles	0.93	1.85	55.12	19.46	0.05
Other chemical products	0.96	2.22	84.83	34.01	0.17
Carpets and rugs	0.97	2.23	19.26	4.09	0.03
Miscellaneous manufacturing nec & recy	0.97	2.39	22.33	13.03	0.20
Animal feed	0.99	2.34	14.74	3.35	0.07
Fish and fruit processing	0.99	2.56	29.87	12.38	0.20
Metal forging, pressing, etc	1.03	2.46	0.00	0.00	0.46
Textile weaving	1.04	1.78	77.76	36.85	0.03
Shipbuilding and repair	1.05	2.36	44.94	28.82	0.10
Ceramic goods	1.08	2.42	42.51	18.75	0.08
Structural metal products	1.09	2.47	13.27	4.56	0.30
Paper and paperboard products	1.17	2.02	15.19	3.99	0.28
Coal extraction	1.22	7.24	33.24	24.76	0.05
Non-ferrous metals	1.32	2.36	73.75	36.90	0.10
Agriculture	1.37	3.96	27.99	11.34	0.96
Metal castings	1.40	2.84	0.00	0.00	0.07
Forestry	1.44	4.18	21.64	6.90	0.03
Glass and glass products	1.53	3.44	33.62	9.55	0.14
Water transport	1.65	5.26	81.65	28.76	0.24
Articles of concrete, stone etc	1.73	2.96	15.97	4.67	0.25
Plastics & synthetic resins etc	1.85	4.57	62.56	15.31	0.12
Oil and gas extraction	1.89	5.73	53.30	30.28	2.06
Textile finishing	1.95	3.34	1.76	0.80	0.03
Other mining and quarrying	2.03	4.64	88.90	61.53	0.16
Industrial gases and dyes	2.03	4.31	49.69	20.32	0.09
Man-made fibres	2.21	4.60	88.19	24.96	0.02
Other land transport	2.21	7.04	7.74	2.33	1.94
Sugar	2.37	3.20	28.83	22.36	0.04
Organic chemicals	2.38	6.27	86.31	31.19	0.17
Air transport	2.39	7.64	53.03	23.82	0.55
Pulp, paper and paperboard	2.42	4.23	66.07	16.52	0.10
Inorganic chemicals	2.58	5.64	34.51	11.75	0.06
Iron and steel	2.69	7.02	55.40	18.32	0.12
Structural clay products	2.73	6.61	3.78	0.63	0.04
Oils and fats	2.86	5.87	38.48	14.49	0.02
Fishing	4.28	12.78	40.35	14.74	0.04
Fertilisers	4.61	13.31	25.69	9.54	0.02
Cement, lime and plaster	9.00	5.00	8.11	1.20	0.05
Electricity production and distribution	16.07	26.70	1.35	0.11	1.08
Refined petroleum	23.44	72.83	25.66	11.75	0.27
Gas distribution	25.36	42.90	0.32	0.18	0.36

*Trade intensity defined as total and non-EU exports of goods and services as a percentage of total supply of goods and services, plus total and non-EU imports of goods and services as a percentage of total demand for goods and services. Output is defined as gross, so the maximum value attainable is 200.