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TRADE, INVESTMENT AND CLIMATE CHANGE SERIES

# Options for Policy-Makers

## Addressing Competitiveness, Leakage and Climate Change

Peter Wooders
Julia Reinaud
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October 2009

This report is a product of IISD's "Bali to Copenhagen" Trade and Climate Change project.

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IISD's Bali to Copenhagen project carries out research, analysis and networking on trade and climate change in six thematic areas: border carbon adjustment, liberalization of trade in low-carbon goods and services, investment, intellectual property rights and technology transfer, subsidies for greenhouse gas reductions and fossil fuel subsidies. For more on IISD's work on trade and climate change see www.iisd.org/trade/crosscutting or contact Aaron Cosbey at acosbey@iisd.ca.

**We gratefully acknowledge the generous support of the governments of Denmark, Finland, Norway and Sweden.**



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## List of Acronyms

| | |
|---|---|
| BCA | border carbon adjustment |
| BTA | border tax adjustment |
| CBDR | common but differentiated responsibility |
| EITE | emissions intensive, trade exposed |
| ETS | emissions trading scheme |
| EU-27 | the 27 countries that are currently member states in the European Union |
| EU ETS | European Union Emission Trading System |
| G77 | Group of 77 |
| GDP | gross domestic product |
| GEM | global equilibrium model |
| GHG | greenhouse gas |
| OECD | Organisation for Economic Co-operation and Development |
| PAMs | policies and measures |
| PEM | partial equilibrium model |
| PPM | process and production methods |
| UNFCCC | United Nations Framework Convention on Climate Change |
| WTO | World Trade Organization |

## 1.0 Introduction

Competitiveness concerns are real, and policy-makers need to confront them as a current priority. The debate during the development of the December 2008 European Union Energy and Climate Change Package, along with the view that the United States will not agree to carbon commitments without protecting its producers, has shown the strength of both feeling and lobbying power among domestic producers. Similar debates are underway in Australia, Canada, Japan and all countries considering carbon reduction schemes.

But is a response to competitiveness concerns a prerogative, or is it protectionism?

The answer is far from simple—among the many issues to consider are whether there are competitiveness impacts in some or all sectors of the economy and how large they are; whether policies designed to reduce emissions in one country would result in increased emissions ("leakage") elsewhere; whether effective policies can be designed to address these concerns or whether there will always be inefficiencies or ways of gaming the system; how protecting parts of the economy will impact the wider economy, domestically and internationally; how we should account for countries' implementing different types of climate policies and varying how much effort they ask the sectors of their economy to make; and whether we should even deal with the competitiveness issue or take competitiveness effects as a natural result of current and historical polluters taking responsibility for their contribution to global warming.

It is also important not to be distracted from wider goals. Will responses to competitiveness concerns help or hinder efforts to reduce greenhouse gas (GHG) emissions? And how will they affect development, particularly in those countries that most need it? A key consideration is whether the potential responses to competitiveness[1] will bring developing countries to the negotiating table with concrete offers of action or, conversely, whether they will be interpreted as protectionist and act as disincentives to engagement by developing countries.

Good policy-making requires a move away from intuitive or single-issue thinking toward evidence-based, holistic considerations; these need to include the full range of policy options and the details of their design. As ever, it is in the details where the devil lies.

### 1.1 Background

Carbon mitigation commitments vary widely in type and stringency. Hence, the costs of complying with them differ markedly. Different costs for producing goods then give rise to competitiveness concerns when producers in countries with relatively strict carbon commitments (and thus increased costs) worry about losing out to producers with lower cost increases. Policy-makers worry both about this loss in competitiveness and about leakage, wherein some or all of the domestic emission reductions brought about by their policies "leak" as increased emissions elsewhere. While closely related, these

1 This paper considers six options (see Section 4): three border carbon measures—border taxes, mandatory allowance purchases by importers and embedded carbon product standards—and three alternative options—aid to industry, free allocation and sectoral approaches.

two concerns are distinct. Leakage relates to the environmental effectiveness of a policy, while the concern over competitiveness is, in contrast, economic.

The United Nations Framework Convention on Climate Change (UNFCCC) negotiations, while at this point uncertain in their final outcome, seem destined to create a regime wherein carbon commitments will vary by country for the foreseeable future. An international scheme, with all countries accepting caps on their greenhouse gas emissions and international emission trading leading to a single world carbon price, may develop at some point in the future, but is widely held to be at least 20 years away. In the meantime, a variety of schemes are being implemented or have been proposed: the European Union Emission Trading System (EU ETS) has been operational since 2005, and similar schemes in Australia, Japan and parts of North America have either been implemented or are close to implementation. Other countries have adopted different means of limiting emissions (for example, China is currently focusing on renewables and improving energy efficiency) or have yet to implement policies. Depending on the type of scheme or policy implemented and the stringency of the commitments made, different national and sectoral carbon costs will be part of the ongoing landscape.

The answer to competitiveness concerns can seem straightforward. A common thought process begins with the idea that sectoral approaches are the best answer. The assumption is that sectoral approaches would equalize policy, and hence costs, in all countries. A transnational sectoral approach with full trading of emission allowances among countries would indeed accomplish this, but countries that are parties to the UNFCCC have expressed views that implementation of such an approach is highly unlikely. The alternative forms of sectoral approaches that are under more active consideration—approaches mainly focused on sectoral crediting or technology agreements—would typically have only a minor impact on the cost differential driving competitiveness and leakage concerns. Indeed, sectoral crediting schemes, such as a proposed sectoral clean development mechanism, may *increase* the cost differential by making payments to developing country producers above their costs of carbon abatement.

The next step in the thought process is that a tax, or some other form of "border carbon adjustment" (BCA), should be applied so that imported goods bear the same burden as those produced domestically. Deeper consideration reveals serious questions: how should the "embedded carbon" within an imported good be calculated, and is the data available to do this? Would BCAs be WTO compliant, particularly if they seek to distinguish by country? Would companies, many of which are multinational, be able to subvert rules by importing semi-finished products or rerouting export pathways? Are BCAs the best way to deal with competitiveness concerns, or should we consider other measures, such as free allowances or other forms of industrial support?

The situation is further complicated by the UNFCCC provisions that will probably allow countries to reduce their emissions in ways that are "nationally appropriate." If an international agreement is concluded at Copenhagen or soon after, we can expect the costs to producers to continue to vary by country. Simplistically, costs will be tend to be higher in the developed world than in the developing world, since negotiators expect that developed countries will need to take the lead over even rapidly developing economies such as China, India or Brazil in mitigating emissions. Nevertheless, the international agreement also must account for equity issues surrounding, among other things, the ability to pay for emission reductions, as well as historical contributions to global warming. It is far from clear that adjusting for competitiveness concerns via trade measures would or should be permissible after the conclusion of an international agreement.

## 1.2 Status of this paper

The International Institute for Sustainable Development (IISD) has a major Trade and Climate Change program running through 2008 and 2009. "From Bali to Copenhagen" is a two-year program of research and consensus-seeking on trade and climate change. One of the focus areas was originally designed to consider BCAs, but research showed that possible responses to competitiveness and leakage concerns should include a wider range of options.

The issues are changing with notable speed. When research on this paper started in autumn 2008, the European Union was proposing a major shift to auctioning as an allocation method, and the U.S. debate was concentrated on the provisions proposed in the Dingell-Boucher and Warner-Lieberman bills.

This paper was completed in October 2009. It includes views from project consultations held in Thailand, South Africa and Brazil in April and May 2009, and in Norway in September 2009.

## 1.3 Objectives and structure of this paper

This paper aims to present the options policy-makers have when addressing competitiveness and leakage relating to the mitigation of climate change.

The issues faced have much in common worldwide: the sectors that have the highest competitiveness concerns tend to be the same for all countries and compete within the same world market. All policy-makers share the same concerns for protecting domestic employment, and though the scales differ, all have been impacted by the financial crisis.

This paper takes a structured and objective approach, seeking to identify the scale of the problem, the options that could be employed to address it and the wide range of impacts the policies could have. (Impacts are not only economic: environmental and political impacts are among other key concerns.) It uses empirical information where possible, backing it up with the necessary economic theory needed to analyze the options. The paper takes account of the wide and growing literature on the topic and of the options that have already been implemented (notably in the European Union) or are being proposed (for example, the U.S. House of Representatives' Waxman-Markey bill and the Senate's Kerry-Boxer bills).

We build on IISD's Border Carbon Adjustment paper of June 2008 (Cosbey, 2008), which identified five questions to which further research and consultation should be directed:

1. Are competitiveness and leakage a problem?
2. If competitiveness and leakage are to be addressed in some sectors, what are the options?
3. What are the economic and environmental effectiveness of the options, and what impact does option design have?
4. Which options would be legal under WTO rules?

5. If competitiveness and leakage are a problem for some sectors, should they be addressed?
    a. What political impact would the options have? What are the perspectives of both developed and developing countries?
    b. Are competitiveness changes and leakage a natural result of reducing GHG emissions in a world where countries are responsible for different proportions of historic, current and projected emissions?

Following definitions of competitiveness and leakage presented in Section 2, we answer these questions in Sections 3 through 7 of this paper. From the findings in those sections, we draw conclusions in Section 8 to give guidance to policy-makers on the options available and their impacts.

## 2.0 Defining competitiveness and leakage

Competitiveness is a comparative concept, aimed at describing the ability of a firm, economy or other aggregation to supply a certain market. It is not measured directly. A loss in competitiveness can be defined as a loss in international market share and/or a loss in profit (Reinaud, 2005a; 2008b). In the climate change field, competitiveness is most often applied at the level of an economic sector, comparing, for example, the chemical or pulp-and-paper industries among a number of countries.

Competitiveness concerns arise from the variation among countries' climate change policies and measures (PAMs). At the simplest level, when one country's policy results in a cost for carbon and another country's does not, the first country may lose competitiveness in the international marketplace. This is illustrated schematically in Figure 2.1 for two producers of a homogenous, internationally traded product (such as cement of a certain specification), one of which is an Annex I country that has agreed to emission reductions. In the example, if carbon emissions cost nothing, the production-cost advantage of the non–Annex I country is not sufficient to overcome the cost of transporting the product to the Annex I country. When a carbon cost is added to the Annex I country's production cost, importing production from the non–Annex I country becomes more economical.

**Figure 2.1 Production costs for two producers, one with a carbon cost and one without.**

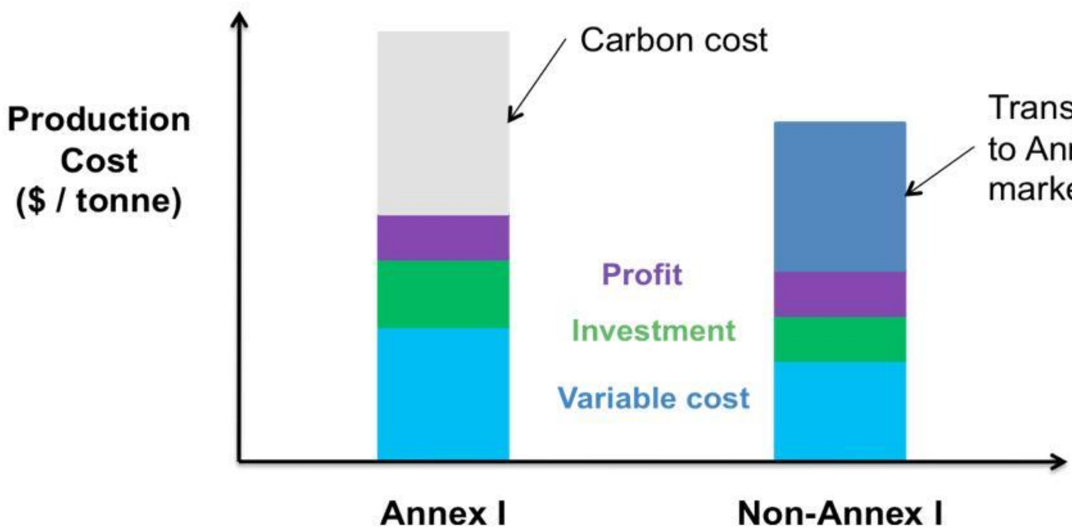
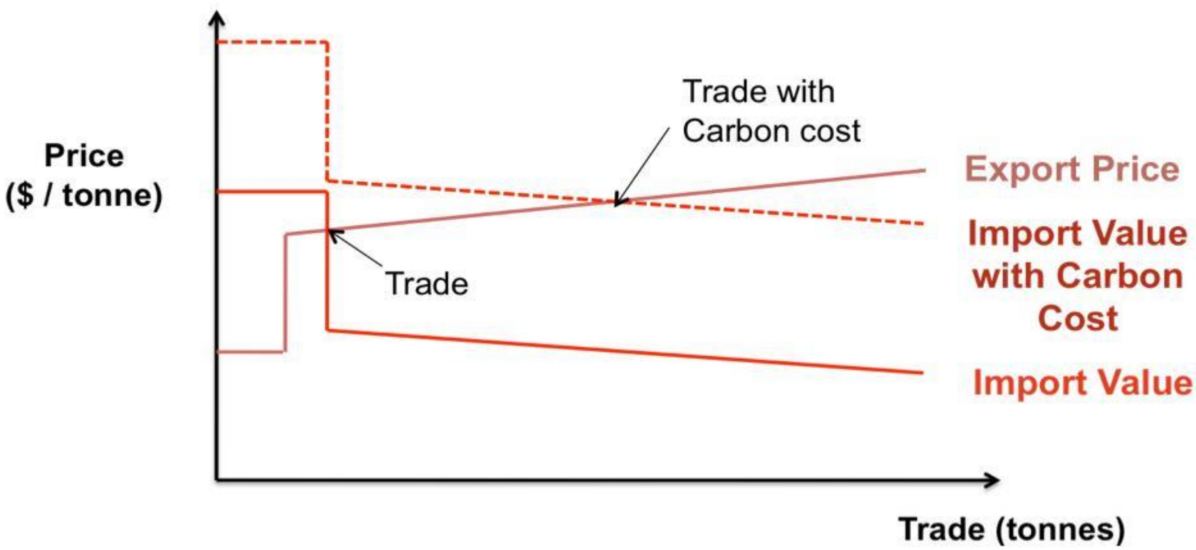



Figure 2.1 shows a market with two firms, where the addition of a carbon cost to the Annex I firm made it more cost-effective to import from the non–Annex I country. In reality, many more firms are generally in a market, with production costs ranging across a continuum. Figure 2.2 illustrates how carbon costs could alter trade, and hence relative production, between a country with a carbon cost and one without. The "Export price'" line indicates the price at which the country without a carbon cost would be willing to sell its surplus production in the importing country. The price includes transport costs, and it rises as higher-price producers or transport routes are required. The price changes stepwise when it is no longer possible to increase production from existing plants and

new plants must be built. The "Import value" line indicates the marginal savings in production costs the importing country would achieve by reducing its domestic production. At first this is high, when imports allow the country to avoid constructing new plants; it shows a stepwise reduction when the avoided production begins to come from existing plants.

The point where the two lines cross shows the equilibrium level of trade. If the importing country implements a carbon cost, the value of the importer reducing its production increases for all producers. The importing country has become less competitive and finds it more cost-effective to reduce its production and import more from the country without a carbon cost.

**Figure 2.2 Change in market equilibrium from introducing a carbon cost in an importing country.**




The schematics shown above are extremely simplistic and miss points critical to the economic analysis. For example, not all climate change policies give a readily calculable carbon cost. A carbon tax is clearly an additional cost, directly related to GHG emissions. If a firm's emissions are covered by an emission trading scheme (ETS) and the firm has to pay for these allowances (rather than receiving them for free), then again, a readily calculable carbon cost results (though this cost will change over time as the market price of allowances in the ETS changes). However, a wide range of other policies and instruments aim to reduce GHG emissions, including technology standards, voluntary agreements between governments and industry to reduce emissions, energy-efficiency commitments, and the need to use at least a minimum amount of renewable energy in the fuel mix. Each of these will tend to result in increased production costs, but calculating the exact cost is difficult.

Costs from taxation of a firm's emissions, or from its need to cover its emissions by purchasing allowances under an ETS, are termed direct costs. But climate policies are also likely to alter costs of other inputs to production, notably electricity,[2] other commodities and goods, and transport. The inclusion or exclusion of these indirect costs can be important for certain producers, notably aluminum and other electricity-intensive industries.

The impact of a carbon cost also depends on market structure. In some markets, producers are able to pass on some, all or even over 100 per cent of their extra costs to consumers. In these cases, carbon costs may have little negative impact on competitiveness—indeed, they can even lead to increases in profits—that is, windfall profits. The ability to pass costs through is specific to markets and products and may differ within a country (notably if the land-transport costs of a product are relatively high, where competitors close to ports and rail terminals would be more exposed to competition). How emissions are allocated (whether for free or via auctions, and what rules govern new entrants and plant closures) has a major impact on how exposed firms are to carbon costs. Section 3.2.1 expands on these critical issues.

Impacts change over the short and long term. In the short term, there is a limited opportunity to alter production quantities in response to changing market conditions: the only option is to alter production from existing plants. In the long term, changes in relative production costs among countries will alter the decision as to where new plants should be built and whether existing plants should be refurbished.[3] Firms may also engage in measures aimed at defending market share, such as lowering their prices below those of importers, but it is difficult to maintain such policies over the long term.

A huge number of other factors affect the competitiveness of firms and countries—the playing field is far from level, even before the introduction of climate change policy. Some of the factors are financial, such as prices for energy, electricity and labour; the cost of borrowing capital; and taxes. Others include geographic location (which defines the costs for access to export markets and of access for importers), the legal and regulatory environment, and marketing abilities. The exact impact of any of these factors on competitiveness is difficult to assess; by the same token, so is assessing the independent impact of climate change policy.

It is clearly very challenging to measure competitiveness or leakage for a particular market or sector. It is even more difficult to estimate the impacts of a single policy such as the imposition of a carbon cost. Section 3 expands the analysis.

We have so far concentrated on competitiveness and said little about its sister concern—carbon leakage. Good policy-makers should clearly be concerned if emission reductions made in one country are fully or partially offset by increases elsewhere. Again, it is important to define the terminology and employ empirical and theoretical analysis.

Fundamentally, carbon policy is designed to reduce the use of carbon-intensive goods and to encourage production processes that abate (reduce) some of their emissions: these impacts are desired. It is not desired for carbon policy to result in competitiveness-driven carbon leakage, where production moves abroad either in the short term (through production decisions concerning existing plants) or in the longer term (when new plants may be built in different countries).

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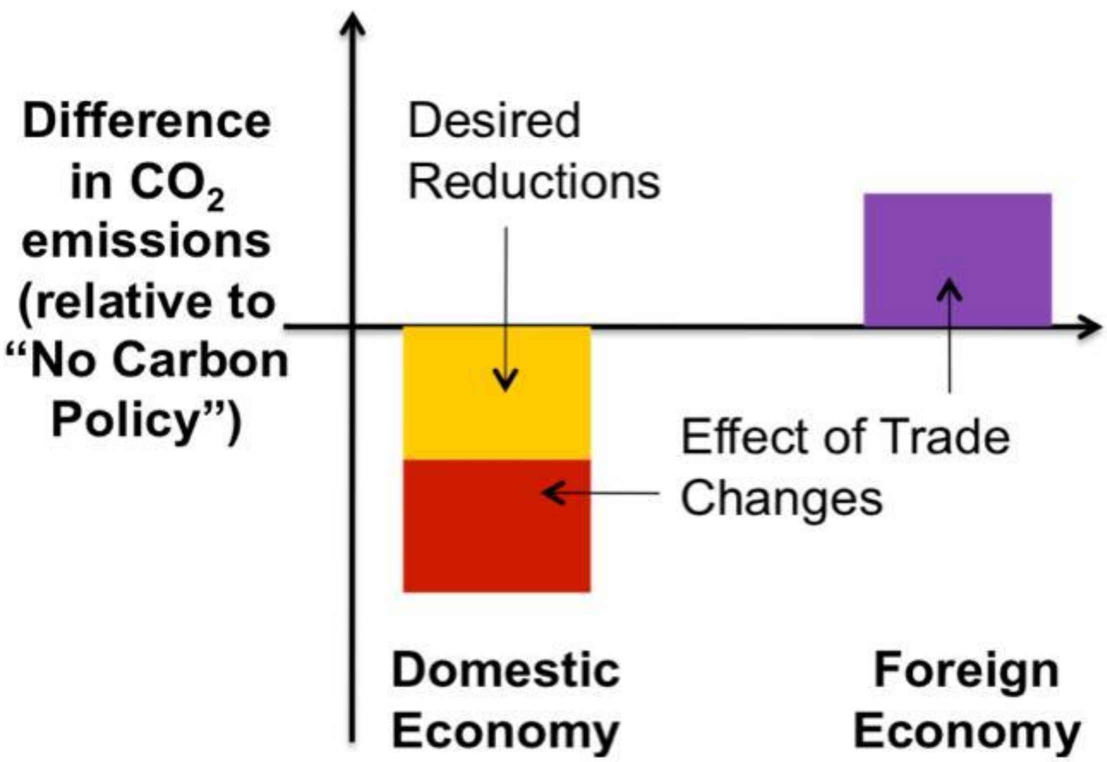
2 Electricity generators are likely to pass at least some of their carbon costs on to wholesale electricity markets (see, for example Reinaud, 2003).

3 See, for example, Reinaud (2008a) for a description of the issues driving investment and refurbishment decisions.

Figure 2.3 illustrates the issues. When a country introduces a climate change policy within the domestic economy, the price of goods rises, and their consumption falls. Producers also have incentives to invest in carbon abatement. Both of these effects are desired impacts of climate change policy and lead to desired reductions of GHG emissions in the domestic economy. What is not desired by the domestic economy policy-maker is for its producers to lose competitiveness, and thus market share, to countries that have not implemented a climate change policy. The reduction in production would reduce emissions further in the domestic economy but increase them in the foreign economy, as well as increasing emissions from the transport associated with the extra trade.

**Figure 2.3 Carbon dioxide emissions changes following a carbon cost applied only in a domestic economy.**



Because of a loss in competitiveness, the domestic economy has lost market share and profit to the foreign economy—the resulting job losses are an important consideration for policy-makers, particularly in times of economic downturns. Leakage also makes the scheme less effective in reducing emissions globally. The most common measure of leakage is essentially a measure of GHG emission changes resulting from changes in competitiveness: the IPCC (2007) defines leakage due to a particular policy thus:

$$leakage = \frac{\text{(increase in emissions outside the country)}}{\text{(decrease in emissions inside the country)}}$$

In other words, the amount of leakage is represented by the size of the second column in Figure 2.3 relative to the first column: the higher the increase in trade, the higher the leakage value.

Figure 2.3 identifies one channel of carbon leakage—competitiveness-driven leakage resulting from a decrease in short-term international market share. The size of its impact is a function of three main factors:

1. *The type of emission cap*. If the domestic economy in Figure 2.3 has an absolute cap on its GHG emissions, the movement of production abroad will free up the GHG emission allowances previously used by the domestic producers and allow its use by other capped producers (in whatever sector of the economy). This will reduce the need for the domestic economy to reduce its emissions and will lead to relatively high levels of leakage. In contrast, if the domestic economy had an intensity-based cap, leakage would be limited to the difference in emission intensity between the domestic and foreign producers.
2. *The relative carbon intensity of production* (that is, tonnes of carbon dioxide equivalent per tonne of product).[4] While there are cases where foreign imported production is more carbon intensive than domestic production,[5] in many others production techniques and technologies are similar, or the importer has a lower carbon intensity (often because their plant is more modern).[6] Yet even if the carbon intensity of foreign production is lower, carbon leakage would still occur as emissions are displaced from one region to another.
3. *The increased transport emissions that come from increased trade*. These are not always included in studies or estimates. When they are not included, leakage is underestimated.

4 Represented schematically by the difference in the size of the red and purple columns in Figure 2.3.

5 A much-referenced case used by those trying to compare "dirty" foreign production with "clean" domestic production is that of Chinese steel compared with U.S. steel. In Houser, Bradley, Childs, Werksman & Heilmayr (2008, Figure 3.4), total GHG emissions are 60 per cent lower for U.S.-produced steel.

6 Further investigations show that there are difficulties in defining the scope of GHG emissions and then measuring them; for example, should we consider average or marginal production? Should emissions from electricity be based on a grid average or some estimate of marginal production? Does export production come from more modern plants than those used to supply exporters' domestic markets? We consider these issues in more detail in Section 5.2.

But it is wrong to assume that leakage is only driven by a decrease in short-term international market share. In the longer term, differences in cost levels could lead to relocation of energy-intensive industries to countries with more favourable climate policies. This is generally referred to as the "investment channel" for leakage. These two channels are intuitive; other forms of leakage are less so. Reinaud (2008a) also identifies the following:

- The fossil fuel price channel, where a reduction in global energy prices is triggered by reduced energy demand in climate-constrained countries, which, all other things being equal, triggers higher energy demand and carbon dioxide emissions elsewhere.
- Increases in prices of low-emitting feedstocks such as recycled scrap metal, which lower their consumption in non-carbon-constrained countries.
- Lower unitary emissions in new vintages outside the region, as the constrained producers' process innovations may spill over to other regions. In other words, new technologies and processes developed within constrained countries in response to their constraints can then be employed in unconstrained countries.

For a given sector or economy, any of these forms of leakage may be the most important. Results from studies and analyses that do not account for all possible channels of leakage should be treated with caution.

Short-term and long-term impacts from competitiveness channels can be assessed using trade flows as an indicator (Reinaud 2008a). The carbon cost will affect investment decisions—mostly because profit margins erode. Keeping in mind that a myriad of factors influence investment decisions, again, carbon leakage should only be attributed to investments that *would have been* made in the constrained region, but were not, as a result of the carbon cost. Note that the investment channel covers not only the decision on where to locate new plant (which depends, among other things, on whether capacity expansion can be made at existing brownfield or greenfield sites and on the entry and exit costs of relocation). It also covers the investments needed to maintain existing production.[7]

Readers should use considerable care when interpreting a claim that certain PAMs will result in a leakage rate of, say, 30 per cent. First, they must understand the formula that governs the calculation. Is the IPCC formula used, or an alternative? Second, leakage calculations are almost universally based on models—there is very little empirical experience of the impact of differential GHG policies. The methodology and assumptions employed in the model, including those related to how factors other than GHG PAMs will change and interact, are critical drivers of the results it produces. Key factors

7 Maintaining production levels requires cyclical investments to preserve manufacturing equipment. Refurbishment may be a significant cost in industries vulnerable to carbon leakage. As mentioned by Reinaud (2008b), discrete decisions to improve productivity occur typically once every 15 to 20 years. These may include revamping a blast furnace in the integrated steel route to reduce coal consumption, revamping a rolling-mill reheating oven to reduce energy consumption, or moving once and for all from one production process to another, such as switching from wet kilns to dry kilns in cement making. There are also continuous decisions, such as upgrading aluminum smelter cells as they come to the end of their economic life after four to five years. Under asymmetric cost increases that lead companies to decrease production (and potentially close), these companies could first decide not to maintain equipment as often, so as to save such costs. The relative importance of carbon costs vis-à-vis maintenance costs could play a role in such decisions.

include the carbon price(s) assumed[8] and the account taken of how other sectors of the economy will be affected by changes in the sectors covered by the PAM.[9]

A third consideration is the time period the model covers: in the short term, potential is relatively limited for shifts in production, as there is no opportunity to build new plants. In the longer term, new plants can be built, and the potential for shifts in the location of production is much higher. Fourth, readers should consider the details of the scheme design. If a carbon price does result from the scheme, the incentives faced by firms will change depending on whether caps are absolute or relative, whether allowances are granted free or are auctioned, and what provisions govern new entrants, plant closures and updating rules.

Finally, the PAMs that countries have implemented or are planning to implement to reduce their GHG emissions take many forms. PAMs that result in a carbon price will have different impacts than those that lead to a change in technological choice. The EU ETS, which covers approximately half of carbon dioxide emissions from the European Union, is the world's largest multinational ETS. However, it is only one measure in the portfolio of EU PAMs. The application of others relating to, among other things, renewable energy, energy efficiency, product standards, voluntary agreements, and best available technology[10] alters the cost structure of both the electricity-generation and energy-intensive industrial sectors covered by the EU ETS, as well as those less-energy-intensive sectors that lie outside the system. Other countries and regions have also implemented or are planning to implement their own portfolios of PAMs to reduce GHG emissions. Prominent in the discussions are China's commitment to reduce its energy intensity by 20 per cent over the period from 2006 to 2010,[11] Japan's support of technology-oriented approaches,[12] South Africa's Long-Term Mitigation Strategy (van Schalkwyk, 2008) and the U.S. Waxman-Markey bill.[13] Each of these PAMs adds its own tilts and undulations to the playing field, and all must be taken into account in order to fully assess impacts from leakage and on competitiveness and environmental integrity.

8 Of course, carbon prices in different schemes will likely differ, perhaps significantly. The prices of allowances under the EU ETS and the United States' Regional Greenhouse Gas Initiative differed by a factor of five as of June 2009, even though both are examples of emission trading schemes (prices taken from www.pointcarbon.com).

9 Such impacts can be non-intuitive. For example, a carbon constraint in one country may serve to reduce fuel demand in that country, reducing world market prices for the fuel and leading to its increased consumption.

10 See European Parliament (2008) for a full description of the European Union's package of policies and measures.

11 See details of China's 11th Five-Year Plan (www.china.org.cn/english/features/guideline/156529.htm).

12 See, for example, the Asia-Pacific Partnership on Clean Development and Climate, within which Japan has a prominent role (www.asiapacificpartnership.org/english/default.aspx).

13 H.R. 2454: American Clean Energy and Security Act of 2009. The bill includes a large portfolio of measures, from cap-and-trade to energy efficiency to sectoral policies in areas such as transportation and power.

# 3.0 Is there a problem with competitiveness and leakage?

Empirically we know little about the impacts on the competitiveness effects of differential carbon PAMs. The EU ETS has been the only major scheme leading to significant carbon prices in place thus far, and it has been operational for less than five years; the literature shows that it is difficult to distinguish any competitiveness impacts to date, particularly because the vast majority of emission allowances were given free.[14] Differential carbon prices are only one reason why the competitive position of one country differs from that of others. Other environmental regulations, employment and planning law, health and safety, and general fiscal policy are examples of many of the other reasons why industry chooses to produce where it does. We would almost certainly be unable to disentangle the contribution of differential carbon prices to competitiveness concerns even if we had many years of good data from many countries. Uncertainty will be part of the picture going forward.

Theoretically we know a little more, and ongoing research is improving the picture. This research has made clear that only a small proportion of economic activity (most studies indicate no more than 1 per cent) is at risk for any significant change in production costs if carbon costs differ between countries. The literature[15] shows that this includes the cement and lime, aluminum, paper, refining, and iron and steel sectors; other sectors may be important in other countries.[16] For the rest of the economy (generally at least 99 per cent), the amount of carbon embedded in products is not significant enough to result in any material increase in production costs.

The impacts on competitiveness resulting from increases in production costs are less clear; even within the small fraction of the economy affected, the picture is highly sector specific. Competitiveness impacts are highest where products are homogenous, where transport costs are low relative to the value of the good and where markets are highly competitive (with many competing producers, low import tariffs and so on). Actual markets are much less "perfect": in many cases domestic producers would be able to pass through at least some, and possibly a large proportion, of the cost increases they face from carbon commitments.

## 3.1 How firms react to carbon costs

It is not possible to fully understand the competitiveness and leakage debate without understanding some of the economics behind how markets will react to carbon price signals.

Section 2 noted that a wide range of factors would affect competitiveness in a real situation. Figures 2.1 and 2.2 illustrated that the competitiveness of countries would change if only one had a carbon cost, and that this would result in a change in the level of trade between them.

If there is a cost of carbon, either from a carbon tax or a market price of carbon from the EU ETS, we would intuitively expect the reaction of firms to be somewhere between absorbing this cost (by lowering profits) and passing it on to consumers as higher product prices. Firms would clearly favour

14 See Section 3.2 for a full review of the evidence from the early years of EU ETS operation.

15 See section 3.3 for a selection of key examples.

16 For instance, energy extraction and production in countries with major energy production, and agriculture in countries such as Australia and New Zealand.

the latter. This analysis is too simplistic: in reality, a number of factors drive how firms would react and what the impact would be on the market. The three most important of these, described in more detail below, are:

- What *type of cap* firms have (absolute or intensity based) and which firms are covered by the scheme.
- *Allocation rules* covering processes such as updating, new entrant provisions and closure provisions.
- *Market structure*, that is, whether the market is supply competitive or dominated by a limited number of players, and how consumers alter their demand as price changes.

### *3.1.1 Type of cap*

There are two types of caps: *absolute* caps limit a producer's emissions to a fixed level, independent of the amount of goods they produce, and *intensity-based* caps impose a limit per unit of production. For example, an intensity-based cap might limit emissions to 1.8 tonnes of carbon dioxide per tonne of steel produced. Producers tend to favour intensity-based caps, since such caps give them the option of increasing their production of goods without penalty.

The cap type is a fundamental driver of a firm's behaviour: if the firm has an absolute cap on its GHG emissions, economic theory suggests that it will react in a fundamentally different way than if those emissions are governed by an intensity-based (per unit, or output-based) cap.

Firms seek to optimize their performance. As a first-order simplification, we can reduce this optimization to establishing the production level at which it maximizes the firm's profit. When considering whether to increase or decrease its production under an absolute cap, the firm will compare its marginal revenue with its marginal costs.[17]

#### *3.1.1.1 Absolute caps*

An absolute cap is independent of a firm's production level. If the firm produces an extra unit, it will need to buy extra emission allowances to cover this increased output. Conversely, if it decides to reduce its output by one unit, it will be able to sell the leftover emission allowances. In both cases the firm will factor the value of the emission allowances into its decision. In economic parlance, this value is referred to as the "opportunity cost"—the firm's cost for altering its production level either up or down. Importantly, it does not matter how the firm originally received its allowances. Whether these were bought at auction or given free, the firm will still factor the opportunity cost of carbon into its production decisions. This is somewhat counterintuitive: we might expect that firms would factor in a carbon cost equal to the market price reduced by the share of their allowances they received for free. They could do this, but it would not be an economically rational strategy.

17 *Marginal* essentially means incremental—it is the concept of looking at small changes. For example, the marginal cost of production is the cost of producing one more unit.

#### 3.1.1.2 *Intensity-based caps*

The incentives for a firm that is subject to an intensity-based cap are very different. Here the firm does not receive any allowances in advance, either free or under an auction. Rather, the firm must compare its actual, measured performance (in terms of GHG emissions per unit of production) to its cap, and then make good any deficit or receive payment for its overperformance. The firm is able to alter both its level of production (for instance, by using only its least-carbon-intensive plants) and will also invest in carbon abatement measures to reduce its GHG emissions per unit of output. Establishing the profit-maximizing production level for the firm depends on the carbon price, the firm's abatement opportunities and its portfolio of production plants. What we can generalize is that the simple opportunity cost of carbon is not the same as if there were an absolute cap.

Economic theory (for example, Demailly and Quirion, 2005) shows that the economic cost of reducing a unit of GHG emissions under an intensity-based cap is higher than the cost of reducing it under an absolute cap. The option of reducing production to meet the cap has been removed, and the loss of options increases compliance costs. Analysis is also more complex than in the absolute-cap case, making it is more difficult to predict the impacts under intensity-based caps. If price caps, price floors or other market constraints are added, it is possible to arrive at a scheme where the incentives on firms may be counterintuitive.

#### 3.1.1.3 *Output-based rebates*

Output-based rebates are a hybrid of the absolute and intensity-based caps discussed above. Absolute caps are applied to producers, but these producers then receive "output-based rebates," that is, rebates based on their output levels.

The analysis above stated that firms faced with absolute caps would always factor the effective cost of carbon into their production decisions, whether allowances are granted free or auctioned. For firms with output-based allocation, the effective cost of carbon decreases as a function of the allowances for which they receive rebates. Thus a firm rebated 50 per cent of their emissions would face an effective carbon cost of 50 per cent of the market price; a rebate of 100 per cent (envisaged under the U.S. Waxman-Markey bill as the average for sectors considered at risk of leakage) would reduce the effective carbon cost to close zero. In other words, the firm would have no economic incentive to reduce its emissions.

By reducing firms' effective costs, output-based rebates would reduce competitiveness and leakage impacts. But they would do this at the cost of also reducing the incentives firms have to reduce their emissions. The higher the level of rebate, the greater the reduction in competitiveness and leakage impacts and the lower the abatement of GHG emissions.

### 3.1.2 *Allocation rules*

Emission trading schemes with absolute caps (notably the EU ETS) generally include provisions relating to how emissions are allocated to firms based on their previous allocations; that is, how allocation is updated. The schemes also make provisions for new entrants and set rules governing what happens when plants or facilities close.

In many cases a firm will be granted some emission allowances in the future, dependent on what its production is in the present. This dilutes the effect of the carbon price signal, because if a firm sees a market carbon price of $20 per tonne of carbon dioxide, but knows that an extra unit of production will likely lead to an emission allowance in five years, when the next allocations are set, it should discount the present value of this future emission allowance from its opportunity-cost calculation.

Consider the hypothetical example of a firm that faces a current carbon price of $20 per tonne of carbon dioxide, but knows that emitting now may lead to it receiving an allowance valid for its emissions in five years. If the firm discounts its costs at 10 per cent per year over the five years, assumes there is a 75 per cent chance of there still being an ETS in the future and assumes the price of an emission allowance in five years will be $30 per tonne of carbon dioxide, the expected present value of the future allowance would be $14 per tonne of carbon dioxide. The effective carbon cost faced by the firm in this case would thus be only $6 per tonne of carbon dioxide.

This example is clearly highly scheme specific, but illustrates a key point: when considering compensating firms for the impact of carbon costs, policy-makers should take into account whether the carbon cost of a firm has already been diluted by the scheme's allocation rules.

### *3.1.3 Market structure*

The structure of both supply and demand are key considerations. A firm is more able to pass through carbon costs in the form of higher prices when its market is less competitive. While the patterns are difficult to generalize, energy-intensive industry tends to be dominated by a relatively small number of players, with market structure probably closer to a monopoly than to full competition. Firms are also better able to pass through costs when the demand for the product is relatively inelastic (that is, when demand is little influenced by price).

Proposing the shape and slope of supply and demand curves is straightforward in theory, but much harder in practice. The curves are also sector specific. This specificity and practical difficulty leads to a key conclusion: attempting to model expected levels of competition and leakage to any level of precision is essentially impossible. Policy-makers thus tend to use much simpler indicators of whether a sector is at risk of competitiveness impacts and leakage, and they devise simple algorithms for how the sector should be compensated for an assumed loss.

Sijm, Hers, Lise and Wetzelaer (2008) provide a detailed primer on the economics and how they affect competitiveness and leakage.

## 3.2 Setting the compensation level

It is important when considering potential compensation to account for the cap type and allocation. If the cap is absolute and the pass-through cost is relatively high, then the government should not allocate many allowances to the firm for free or it will risk overcompensation. Such "windfall profits" received much attention during the first phase of the EU ETS (from 2005 to 2007). From these profits many analysts concluded that some sectors (notably electricity generation) were able to pass through a very high proportion of the opportunity cost to consumers, yet were still receiving for free essentially all of the allowances needed to cover their emissions.

We previously noted that rational firms use the opportunity cost of allowances when deciding on production decisions in the short term, and that detailed allocation provisions could dilute the impact of the carbon cost faced by firms, which they should not be compensated for again. We also noted that the level of cost pass-through is an essential element when understanding how firms are affected, though it is very difficult in practice to simulate exactly what the expected cost pass-through would be. It is therefore extremely difficult to set a "correct" level of free allowances for a sector that will compensate firms for some or all of their loss of producer surplus resulting from carbon costs.

Policy-makers must also consider the impact of granting free allowances to companies. In the short term, the opportunity cost argument shows that whether allowances are received free or paid for makes no difference to the optimum production level. In the longer term, a firm that received allowances for free would have a stronger financial position than one that had to pay for them under an auction. However, receiving allowances for free has much in common with receiving a cash payment—what the firm decides to do with the payment is up to the firm. It may see the payment as evidence of the commitment of the host government to retain it as a producer; however, it may also pay extra dividends to its shareholders or use the payment to enable it to invest in a new plant overseas.

The impact of compensation payments using free allowances clearly depends on the value of the payments made. If these are large, they may enable the firm to maintain lower costs of capital for investment. In some cases, making a compensation payment may have no impact on where the firm decides to locate its next plant, a decision that is driven by other reasons (see Section 2 for a description of drivers of competitiveness). In these cases, the government would not achieve its goals by allocating free allowances.

BCAs aim to apply costs universally, thus levelling the playing field. Even if successful, these policies would raise the price for the product and lower profits. If free allowances are to be used to compensate affected industry, fully compensating industry for its lost producer surplus would give a higher level of protection than BCAs. Again, setting the "right" rebate level is challenging, and the practice will necessarily be inexact.

## 3.3 Evidence of the impacts of climate change policies and measures

A relatively small proportion of developed countries' GDP comes from production of commodities where carbon costs correspond to a substantial proportion of costs. These costs may be direct (associated with the firm's own GHG emissions) or indirect (associated with higher costs of inputs, notably electricity).

Analysis by Hourcade et al (2007) indicates that only 1 per cent of the United Kingdom's GDP is derived from traded commodities whose carbon cost would make up over 4 per cent of that commodity's value added (see Figure 3.1). In the German context, sectors considered to be exposed to competitiveness loss represent 2 per cent of GDP (Öko Institute, Fraunhofer Institute for Systems and Innovation Research, and German Institute for Economic Research, 2008) (Figure 3.2). Both studies assume that a carbon price of €20 per tonne of carbon dioxide would apply. This is only an example—it does not suggest either that this price would occur in practice or that it in any way represents the price necessary to meet a climate goal. The indirect costs of electricity are also significant in many sectors. Again, the associated costs rely on assumptions—here, the researchers apply the grid average electricity factor for the United Kingdom and an emission factor based on coal-fired electricity generation for Germany. In both cases the models assume that 100 per cent of electricity cost increases arising from carbon costs would be passed on to industrial consumers.

**Figure 3.1** **Possible direct and indirect cost impacts of the EU ETS on U.K. manufacturing subsectors, assuming a carbon price of €20 per tonne of carbon dioxide and a corresponding electricity price increase of €10 per megawatt-hour. (2004 data.) Reprinted from Sato and Mohr (2008); adapted from Hourcade et al., (2007).**

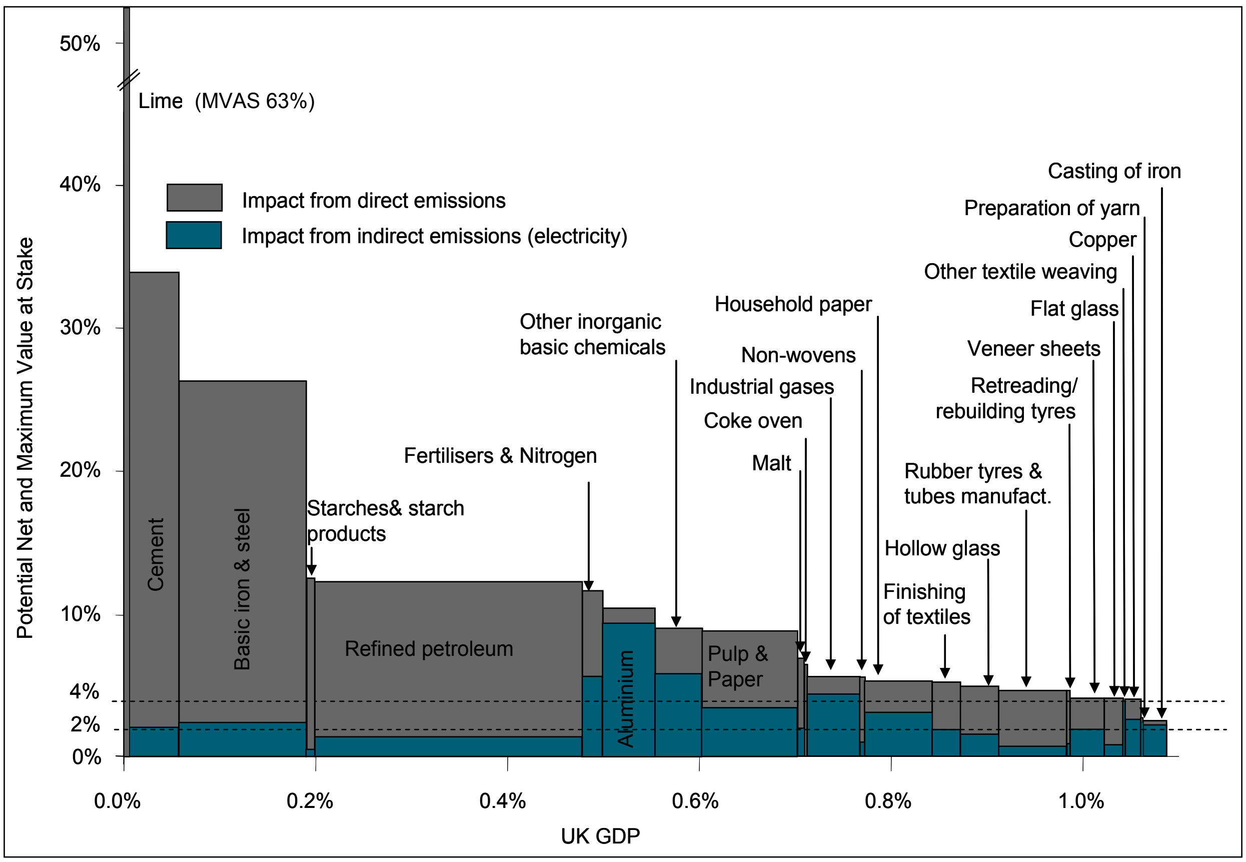
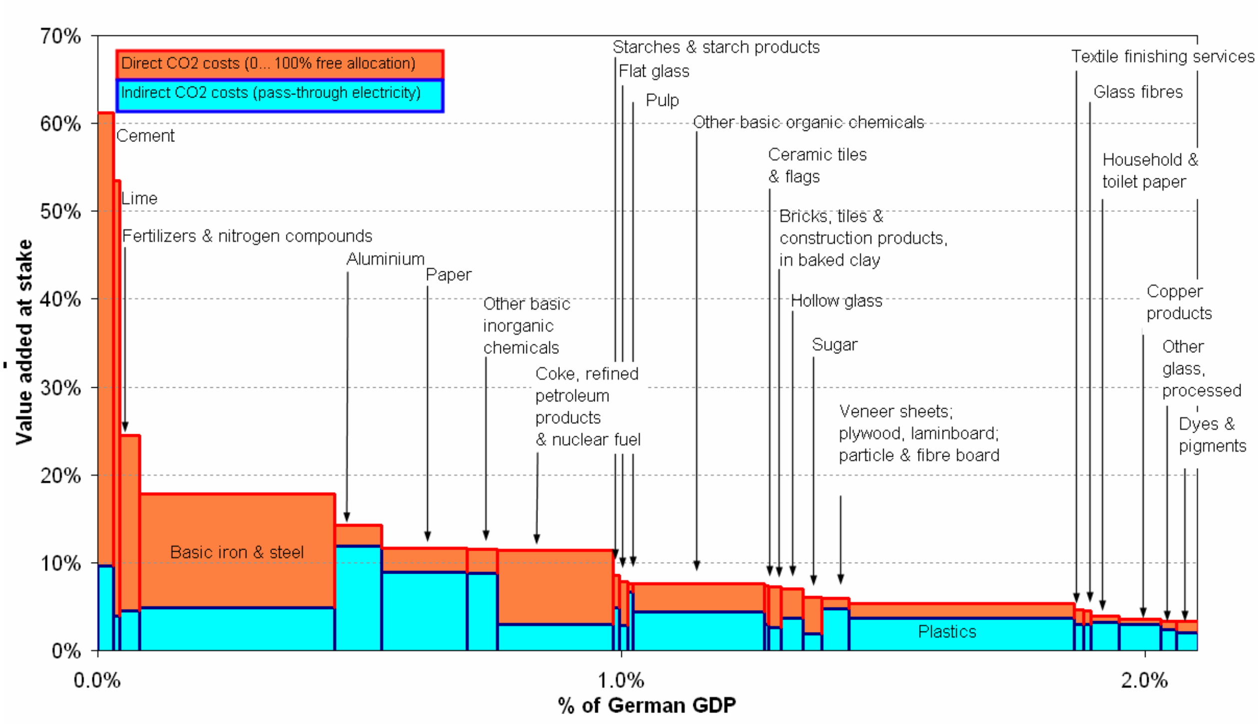


**Figure 3.2** **Possible direct and indirect cost impacts of the EU ETS on manufacturing subsectors in Germany, assuming a carbon price of €20 per tonne of carbon dioxide and a corresponding electricity price increase of €19 per megawatt-hour. (2004 data.) Reprinted from Sato and Mohr (2008); adapted from Öko-Institut (2008).**




Focusing on the impacts of the EU ETS, introduced in January 2005, studies from Reinaud (2005a; 2005b), Hourcade et al. (2007), Öko Institute et al. (2008) and CE Delft (2008) (Figure 3.3) indicate that only some sectors and subsectors of European industry are susceptible to any significant loss of competitiveness and could thus be expected to "leak" if carbon prices reach a certain level. These include lime, cement and clinker kilns; primary aluminum smelters; integrated steel mills and electric-arc furnace ovens; and certain chemicals. Studies from Australia (CISA University of Sydney in Australian Department of Climate Change, 2008) (Figure 3.4) and the United States (Herrnstadt, Ho, Morgenstern & Heilmayr, 2007) (Table 3.1), as well as Aldy and Pizer (forthcoming) also point to a similar set of sectors and subsectors. Of interest is the inclusion in the Australian study of certain agricultural products (both livestock and crops).

**Figure 3.3** **Potential price increase as a percentage of sectors' total costs for Dutch manufacturing sectors. Reprinted from CE Delft (2008).**

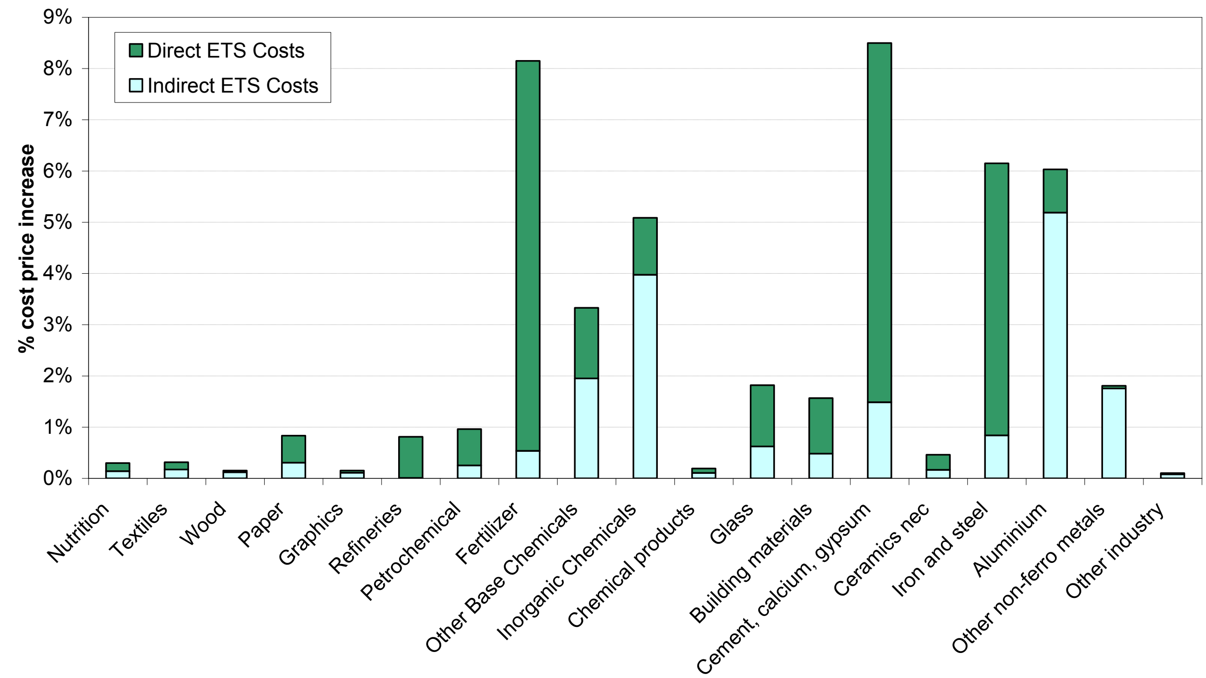
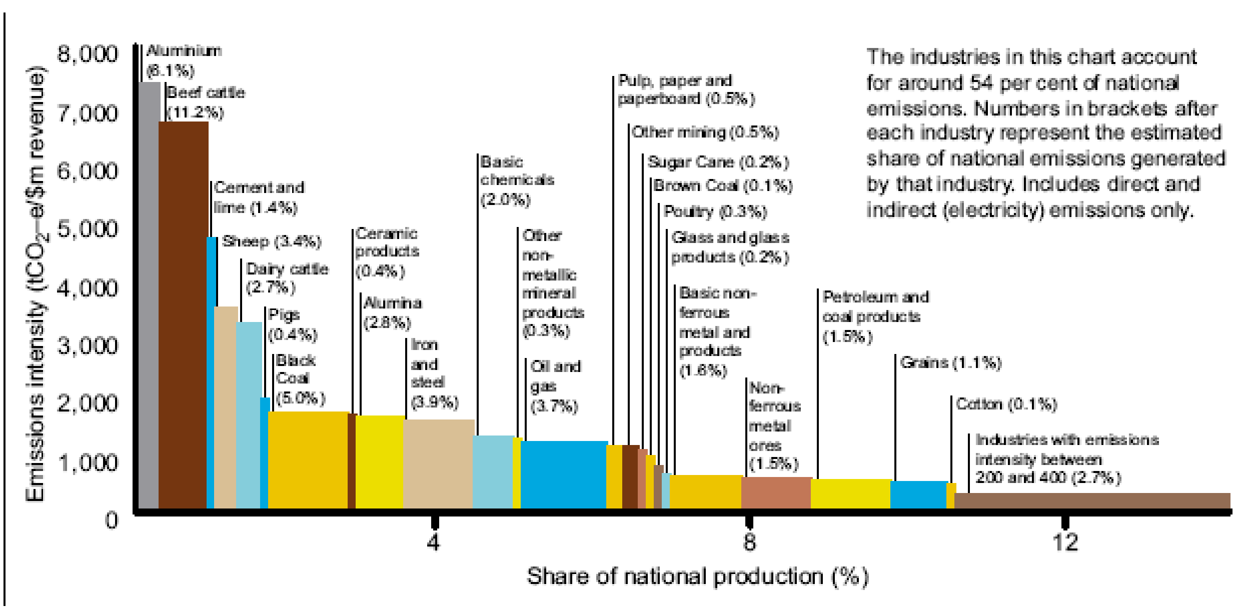



**Figure 3.4** **Preliminary analysis of the emissions per unit of revenue[1] of Australian traded industries in 2001 and 2002. Reprinted from CISA University of Sydney in Australian Department of Climate Change (2008).**




1 This study compares cost increases to with revenue, rather than using the comparison to with value added used in the other studies quoted.

Table 3.1 **Energy costs, import shares and effects of a change in U.S. costs of US$10 per tonne of carbon dioxide. Data from Herrnstadt et al. (2007).**

| Industry | Electricity share of total cost (%) | Import share of total use (%) | Effect of higher energy prices on unit costs (%) | | |
|---|---|---|---|---|---|
| | | | Direct fuel combustion | Electricity use | All immediate inputs |
| **Wood and furniture** | 0.93 | 22.5 | 0.17 | 0.13 | 0.35 |
| **Paper and printing** | 1.49 | 11.9 | 0.85 | 0.25 | 1.11 |
| **Petroleum** | 0.79 | 11.2 | 2.38 | 0.12 | 2.50 |
| **Chemicals and plastics** | 1.46 | 26.7 | 0.34 | 0.28 | 0.45 |
| **Non-metallic minerals** | 1.55 | 16.3 | 0.76 | 0.30 | 1.07 |
| **Primary metals** | 2.15 | 27.2 | 0.89 | 0.84 | 1.58 |
| **Fabricated metals** | 1.09 | 13.6 | 0.06 | 0.13 | 0.53 |

### *3.3.1 Measuring vulnerability*

Competitiveness impacts also differ greatly across the wide range of manufacturing industries. Several elements play out in determining whether a high cost impact in fact translates to a loss in competitiveness. Loss in competitiveness can be measured by a number of proxy measures, including the degree to which a sector can pass on the carbon cost to consumers (Table 3.2).

Table 3.2 **Elements influencing the capacity of companies to pass through costs from an ETS. Data from Reinaud (2008a).**

| Elements | Impact on ability to pass through costs[1] |
|---|---|
| International price-setting | Reduces |
| Intense international competition | Reduces |
| Market concentration | Increases |
| Tight market (i.e., low level of available production for the export market) | Increases |
| Differentiated products | Increases |
| Elastic demand (i.e., price increases reduce demand through demand reduction and/or product substitution) | Reduces |

1 Note that the impact of the elements on carbon leakage are reversed, e.g. if there is international price-setting then carbon leakage would be higher than if price-setting were more localised

At the centre of the analysis is the degree of international competition in the relevant product market. For example, are there barriers to trade? Are freight transport costs high? Is a high level of production available for the international market? Price elasticity of demand, market concentration and product substitutability (both intra- and intersector) also influence the market shares and profitability of manufacturing sectors.

One proxy indicator of cost pass-through capacity, and thus of the potential impact of differential carbon prices on competitiveness, is international trade intensity (trade flows). Sectors like aluminum (76 per cent of world production was traded internationally in 2006) and steel (40 per cent in 2008) are competitive internationally. Other sectors see much less competition at present; for example, only 6 per cent of cement was traded internationally in 2007. Yet assessing competitiveness loss only through trade intensity is of limited help when designing the stringency (that is, setting the cost) of future climate policies. Trade exposure is dynamic in nature. Elements driving competition, such as transport costs, production costs, production availability, and product specifications, change with time. Therefore, past indicators of trade intensity do not necessarily reveal future exposure to international trade.

Similarly, our past experience of carbon prices in markets gives only rough guidance as to what prices we can expect in the future. Carbon prices to date have been driven by the EU ETS, which covers carbon dioxide from only approximately half of the European Union's emissions. The commitment-setting process in the EU ETS relies on a specific methodology and political context. Finally, the EU ETS price has so far only taken account of short-term carbon reduction measures (principally switching coal-fired generation to natural gas), is very sensitive to weather patterns and has been based on a market where only a limited number of installations with capped emissions have been trading actively.

### *3.3.2 Empirical evidence from the EU ETS*

In parallel with the theoretical literature, another branch of research is emerging that looks empirically at the impacts of existing climate policy. The EU ETS has provided a full-size experiment for identifying the magnitude of competitiveness and carbon leakage (Reinaud, 2008a). Since 2005 the European Union has created an ETS that caps the carbon dioxide emissions of power generation, but also of industrial activities whose products, in some cases, are traded internationally.

The emerging methodology tracks carbon leakage by monitoring changes in trade flows and investment decisions, and assesses whether the carbon dioxide cost has had a measurable impact. Had the ETS had an impact, the European Union would have imported more, cheaper products from unconstrained regions and exported less to the rest of the world.

Experience to date does not reveal significant carbon leakage during the first phase of the EU ETS (from 2005 to 2007). The sectors examined—steel, cement, aluminum and refineries—showed no marked changes in trade flows or production patterns.[18] Although some of these sectors, such as

18 See analysis by Reinaud (2008a; 2008b), Ponssard and Walker (2008), Lacombe (2008) and Ellerman, Buchner and Carraro (2009).

aluminum and steel, had been trending toward additional net imports, the evidence suggests that the EU ETS did not impact trade during its first phase.

Carbon leakage is likely to have been limited during the first EU ETS trading period because the free allocation of allowances covered the majority of emissions and were overallocated in some sectors.[19] Leakage was further limited by still-functioning long-term electricity contracts that have softened the blow of rising electricity prices (Reinaud, 2008a; "Emissions Suspicions," 2008). Higher prices for traded products (such as aluminum, steel and refinery products) as well as the relatively short time span of EU ETS policies also did not allow for full observation of carbon leakage. Heavy-industry capital structures are long lived: any large-scale restructuring would not be observable before a longer time period had elapsed. Finally, in some sectors (such as cement), the pass-through of climate policy costs may have been delayed; had companies tried to pass the value of allowances immediately through in their prices, they could have lost long-term relationships with customers. It is too early to say what the expected level of leakage will be. Indeed, it is possible that even with empirical evidence covering many years of data, it may be very difficult to separate out the independent effect that carbon prices have had on leakage.

### *3.3.3 Using models to simulate future impacts*

Two classes of models are used to simulate competitiveness and leakage impacts and the effectiveness of options in reducing them:

1. *Partial equilibrium models (PEMs)* look at a portion of the economy only (for example, the steel sector worldwide), ignoring how the chosen portion of the economy affects and is affected by the rest of the economy. Models tend to be technology rich and developed for a purpose. They tend to have a better description of sectors than the second model.
2. *Global equilibrium models (GEMs)* model the whole world economy. Their strength is that they take account of all the input-output effects among different sectors; their weakness is that they do not model individual sectors in detail.

PEMs have typically been used to estimate what leakage rates could be in certain sectors (notably iron and steel, cement and aluminum, and generally focusing on the EU ETS). We provide a survey of their results below. GEMs have been used more to assess the impacts of BCAs on both individual sectors and the wider economy, notably to include channels of leakage other than competitiveness and investment. We discuss their results in Section 5.

#### *3.3.3.1 Partial equilibrium modelling*

Section 2 noted that the IPCC definition of leakage was the increase in emissions outside the country divided by the decrease in emissions inside the country. It also discussed the care that is needed when

19 Most allowances in Phase 1 (2005 to 2007) and Phase 2 (2008 to 2012) of the EU ETS are distributed free, based on past emissions, expected improvements and product growth in each sector (see Section 4.3.1).

interpreting the results of this definition, noting that the result can only be used as an indication of environmental integrity when an absolute cap is applied within the country in question.

Estimates of leakage are limited, and the studies used are based on models containing a range of differing assumptions. The studies can be viewed as "best suited to understanding the mechanisms ... that may drive carbon leakage" (Reinaud, 2008b).

We have only imprecise and highly uncertain ranges of leakage estimates for some sectors (iron and steel, as well as cement); other sectors potentially exposed to such a risk (such as paper and pulp or chemicals) have not been studied. For instance, a carbon dioxide price of €20 per tonne in the EU-27 could result in leakage rates between 0.5 and 25 per cent in the iron and steel sector and between 40 and 70 per cent in the cement sector—depending, among other parameters, on how allowances are distributed (Demailly & Quirion 2006; Ponssard and Walker, 2008).

The carbon cost applied is generally on the order of €20 per tonne of carbon dioxide. The study by Gielen and Moriguchi (2002) on the steel sector in Japan and the EU-15 shows a doubling of the leakage rate, from 35 to 70 per cent, when the carbon tax applied is increased from US$11 to US$42 per tonne of carbon dioxide. Reinaud (2008b) tentatively concludes that leakage rates of 100 per cent are unlikely. In other words, carbon leakage would never wipe out entirely an effort to reduce emissions in an industry. In addition, in many cases the new installations built in unconstrained regions are more efficient than older installations in constrained regions, lowering the leakage ratio.[20] Demailly and Quirion (in press) add that since PEMs tend to assume that there are no climate policies in other countries, their leakage estimates are at the high end of the range.

Reinaud (2008b) makes the interesting observation that the modelling results are ambiguous on whether higher levels of trade intensity (as seen in the steel sector) lead, as expected, to higher levels of leakage.

Ponssard and Walker (2008) and Demailly and Quirion (in press) provide an illustration of the importance of market-specific conditions. Both pairs of researchers have taken into account the increased costs of serving inland markets with cement. Ponssard and Walker's model separates markets into coastal and inland regions; Demailly and Quirion include a detailed nodal model of ports and demand centres.

The models provide useful insights into how cap types and allocation modes impact leakage and other outcomes. Demailly and Quirion (in press) compare cap types and allocation modes for the European Union, looking at the cement, aluminum, steel and electricity sectors. They consider five different futures for allocation under the EU ETS: pure grandfathering, output-based allocation, auctioning, auctioning with border adjustment,[21] and a combination of output-based allocation in the industry sectors and auctioning in electricity generation. The conclusions regarding output-based allocation are of interest: in line with economic theory, it appears to be the least efficient policy. It effectively reduces the carbon cost faced by firms and thus is an effective tool in reducing leakage. Given that it

20 Yandong and Yutaka (2008) show that the best of China's steel-making plants are 9.2 per cent more energy efficient than the Japanese average and that China's large plants overall are only 7.5 per cent less efficient than the Japanese average.

21 Border adjustment is applied to both imports into the European Union and as a rebate to exports from the European Union, at the level of the best available technology in each industry. Ismer and Neuhoff (2004) claim such adjustments are WTO-legal.

also precludes the option of reducing emissions by decreasing output, Demailly and Quirion note that outcome-based allocation is often promoted by industry. They also note that allocation has an effect on economic efficiency and is only in specific cases an issue of distribution alone; they mention, as an example, that auctioning allowances would give the full price signal to a regulated electricity industry, whereas grandfathering may not. In terms of welfare, they conclude that auctioning with border adjustment is the most efficient policy for both the world and for the EU region, with output-based allocation the least efficient and the other three options closely bunched together in the middle.

Monjon and Quirion (2009) extend the modelling to assess different forms of border tax adjustment (which they refer to as "BA," but which this paper refers to as "BTA"). Their "full" option includes a BTA applied to fuel and electricity as a rebate on exports (based on EU average emission factors). Their "BA EU average" uses the EU average as the basis for the tax in all cases, "BA direct" limits taxes to direct emissions only, "BA import" limits the tax only to imports and "BA import direct" limits it only to direct emissions from imports. The study yields some extremely interesting results. For cement, the leakage ratio is reduced from around 20 per cent under auctioning to around 5 per cent in all options; "BA import direct" retains most of the benefits, since leakage is driven by imports and the contribution of emissions from electricity is low. For steel, leakage of around 40 per cent under auctioning is reversed to –25 per cent under "BA full," with the latter's combination of export rebates and import tariffs allowing EU producers to gain world market share. Results for aluminum also show the potential for this sort of negative leakage, in which emissions increase in the home country while decreasing overseas. The study also compares BTAs with output-based free allocation, concluding that "the performance of different output-based free allocation models reduces leakage compared to auctioning, but it does so *only to a limited extent if compared to border adjustments*" (emphasis added).

The simulations require assumptions about what drives industry relocation (that is, long-term leakage). The degree of mobility of manufacturing activities is not straightforward. From a theoretical point of view, the stringency of environmental policy should matter in determining the location of firms. Yet the empirical literature is somewhat less clear-cut. Multiple factors drive investment, and companies are not operating in a vacuum (that is, focusing only on climate-policy impacts). Looking at today's industrial development and only focusing on carbon costs could oversimplify the picture of what drives industry's location choices.

#### *3.3.3.2 Case study of the cement sector*

Analysis of the cement sector shows how results on leakage are crucially dependent on the values of key data points and on the methodological assumptions made.

Six per cent of world cement production was traded internationally in 2008, generally from short-term capacity excesses (plants are typically built to meet local market needs, with the excess exported). Patterns of export and import change markedly over the short term. Prices for cement in 2008 ranged from US$30 to US$150 per tonne around the world and were typically around US$75 per tonne. Production cost differences explain only a small part of the price range.

Cement is a relatively heavy product whose transport costs are a very important part of market dynamics. International shipping costs increased threefold over the period from 2003 to 2008, and were around US$50 a tonne for the China-U.S. route in 2008. Land-transport costs are on the order of

$10 per tonne for 100 kilometres. Markets tend to involve a small geographical area (such as a part of a country), with the vast majority of cement produced locally. Competition tends to be limited to areas near ports or terminals, and is further limited by consumers placing trust in certain suppliers, who they know produce cement that they have used successfully and have properties they fully understand. This leads to the "Armington elasticity" effect, wherein importers must offer lower prices than established local suppliers. The price elasticity of demand for cement is considered to be low, at least in the short to medium term.

Carbon dioxide emissions from cement are on the order of 0.8 tonne per tonne of cement, with the majority of this (approximately 0.5 tonne per tonne of cement) released during the calcination (release of embedded carbon dioxide) of the limestone feedstock. A carbon price of US$25 per tonne of carbon dioxide would add approximately US$20 to the production cost of a tonne of cement. Options for abating carbon dioxide in cement production are limited, principally to blending cement (with ground granulated blast-furnace slag and fly ash) and using alternative fuels (whose benefits depend on whether or not the fuels are zero-rated for carbon dioxide emissions). Whether the cement sector can take up these abatement options depends on policy support that is outside its control.

Traditionally, cement plants have not been built to serve export markets. In order for significant competitiveness and leakage impacts to occur, the additional carbon price would have to change this paradigm. The carbon price would likely have to be much higher than current market values for this to occur, at least unless current transport costs decrease significantly.

Although relatively simple, this case study illustrates the assumptions and drivers that more detailed models are based upon. Models generally give us a good idea of what the key drivers of results are, but the results they produce are more uncertain, and critically depend on the assumptions made.

# 4.0 If competitiveness and leakage are to be addressed in some sectors, what are the options?

A border tax on imports is an intuitive response to competitiveness and leakage concerns. It would have the advantage of being relatively economically efficient: it is applied directly to the problem we are trying to address (carbon emissions), and thus does not have to concern itself with estimating impacts on consumer prices and on competitiveness. It would, however, be difficult to implement, both technically (life-cycle analysis of even the simplest product has boundary and conceptual issues and would require a high level of resources) and politically (it is unclear whether it would be legal under the WTO, and it would be likely to play havoc with the atmosphere of cooperation necessary to achieve a future international agreement under the UNFCCC).[22]

A border tax applied to imports is only one of the options available to respond to competitiveness and leakage concerns. Six main options exist, within two categories:

- Border carbon measures
  1. Border taxes (on imports and, less commonly, rebates on exports)
  2. Mandatory allowance purchase by importers
  3. Embedded carbon product standards
- Alternative options
  4. Aid to industry
  5. Free allocation (of allowances to domestic producers)
  6. Sectoral approaches

Border carbon measures are applied as international trade measures, whereas alternative options tend to be applied as domestic policies. Sectoral approaches can be domestic or international in their scope.

## 4.1 Border carbon measures

Beyond performance standards, policy-makers currently have two distinct options for adjustment measures: applying a levy (carbon tax) on imported goods or requiring importers to purchase emission allowances. These provisions aim to ensure that domestically constrained manufacturers of GHG emission–intensive goods[23] are not placed at a competitive disadvantage vis-à-vis imports produced under less strenuous emission requirements, thus eliminating carbon leakage. There is little difference between the two options, and we refer to them jointly as BCAs in the rest of this paper.

22 Noting that the UNFCCC has staunchly refused to say what PAMs should or should not take.

23 The examples given below generally propose covering the same set of energy-intensive sectors.

#### 4.1.1 Border taxes and mandatory carbon-allowance purchases

BCAs are being actively discussed in the United States under the Waxman-Markey bill and are included as a future option under the EU ETS (see Section 4.3.1). Although BCA appears to be a simple concept, policy-makers must carefully consider a number of technical, legal and, not least, political details (Dröge, 2008).[24] Further, there may be an inherent tension between reaching the maximum effectiveness of the scheme in addressing competitiveness and leakage and the administrative burden (Reinaud, 2008b).

Sections 3.3.3 and 5 indicate that BCAs are likely to be effective at reducing competitiveness and leakage from the perspective of the sectors they are applied to, but that other effects (notably the fossil fuel–price leakage channel and a loss in GDP in other parts of the economy) mean that their macroeconomic effectiveness is questionable. The detailed implementation of a BCA scheme is critical. From the perspective of the sectors covered, competitiveness loss and leakage would be best prevented if the scheme restored a level playing field by covering all products vulnerable to carbon leakage and introducing the same marginal climate-policy costs for all (that is, covering both direct and indirect costs). In addition to imposing BCAs on imports, the country would also need to rebate the cost of emission allowances for exports. The legislative proposals discussed to date would only apply to some sectors in countries with an ETS. When deciding how to impose a BCA, a number of details should be carefully considered.

*Indirect costs.* While trade-exposed products such as cement and steel manufacturing consume electricity, aluminum's electricity intensity is by far the highest, raising concern about the sector's indirect GHG emissions whenever power is generated from fossil fuels (Baron, Reinaud, Philibert & Genasci, 2007). Therefore, the BCA would need to minimize the climate-policy cost differential for indirect costs. Such a provision is currently included in the Waxman-Markey bill. The EU ETS agreement for the post-2012 period sets up provisions that would allow compensation for electricity cost increases (see Section 4.3.1). Having a clear idea of the role carbon dioxide prices play in electricity contracts is critical before considering compensating for increases in indirect carbon costs. Without such an idea, policy-makers would risk overcompensating companies and undermining their climate policy's ambition (Reinaud, 2008a). The aluminum industry (as well as other electricity-intensive sectors) has been actively pursuing new forms of power contracts in order to access electricity supply at prices below spot prices (Reinaud, 2007); "contracts for difference" and other tools are commonly used to smooth electricity prices against the effects of short-term volatility. Thus it is not clear in liberalized electricity markets how wholesale price increases translate into electricity cost increases for industry. Furthermore, the carbon price is only one factor among several influencing power prices.

*Export rebates.* To effectively address the loss of market share for carbon-constrained industrial products in favour of non-carbon-constrained producers, a BCA would need to address both imports and exports (Reinaud, 2008b). Exports from carbon-constrained countries will need a rebate against their carbon costs if they are to compete on an equal basis in the market they are exporting to. None of the proposals listed above includes such a provision.

24 For a discussion on the WTO compatibility of a BCA scheme, see Section 6.1.

*Products subject to the BCA*. Ideally, the BCA would cover all goods from a given emission-intensive, trade-exposed sector (Reinaud, 2008a). For example, the U.S. Dingell-Boucher draft bill suggested it would include most products from trade-exposed sectors:

> Products that would be covered by the BA include both primary products (i.e. iron, steel, steel mill products, aluminum, cement, glass, pulp, paper, chemicals, and industrial ceramics) and any other manufactured product that (i) is sold in bulk for purposes of further manufacture or inclusion in a finished product; and (ii) generates, in the course of the manufacture of the product, direct greenhouse gas emissions or indirect greenhouse gas emissions.

Nonetheless, expanding the list of goods to increase the amount of leverage a BCA provides is challenging on two fronts. Reinaud (2008a) states: "First, accurately assessing the amount of carbon emitted in the production of a tonne of steel or cement is, in itself, extremely difficult for reasons related to the definition of a sector boundary and monitoring of inputs, among other reasons." For example, some steel mills also produce electricity that is then sold to the grid, making the emission inventory for steel products all the more difficult. Reinaud adds that "doing the same for vehicles, appliances, industrial equipment, toys or electronics would be nearly impossible. As a result, there is an inherent tension between full coverage on the one hand, and administrative feasibility on the other." Given changing technology and regulatory circumstances, some flexibility would also be required to allow for adjustment over time (Neuhoff & Ismer, 2008).

Reinaud continues: "Second, even if an accurate determination of the amount of carbon emitted in the production of a finished good could be made, assigning a price for emissions through a BCA would have a negligible effect on its overall cost." For products in which carbon-intensive components only represent a minor share of overall value—for example, the small iron content of computers—the administrative costs of border adjustment may surpass the benefits of introducing such a scheme.

In the case that only semi-finished products are covered, firms seeking to bypass the adjustment scheme could try to game the system by further transforming their goods to reach a product category that is exempt from the list of covered goods. This could also worsen the competitiveness situation for downstream industry. Considering that more than 60 per cent of primary aluminum ingots are imported into Europe, for example, applying adjustments to all imported ingots would significantly increase the costs of final aluminum products (such as cars and windows) produced in Europe. The adjustments would risk further aggravating the competitiveness situation of downstream industry, where most of the value added of the sector lies—as well as most jobs (at least in Europe).

*Carbon cost baseline*. In an ETS, prices of carbon dioxide allowances vary, as allowances are traded daily. In that sense an ETS affects companies differently than a carbon tax. The costs of the climate policy will be different for each company. They will differ depending on the date allowances (if needed) are purchased on the market and on when companies' electricity contracts were signed, as well as on whether electricity is purchased on the wholesale market. Further complications arise when companies are permitted to buy and sell allowances on the open market and some allowances are provided for free (Genasci, 2008). The baseline for the adjustment would need to be determined on a company-by-company basis to accurately restore a level playing field. Yet having a precise monitoring of each company's climate policy costs would require significant administrative efforts by both governments and companies. Costs vary over the short and long term—policy-makers need some formula (such as an index).

*Encouraging emission reductions domestically.* The impact of domestic carbon prices depends on how allowances are allocated. Pure auctioning gives the strongest price signal, and allocating allowances for free tends to weaken the signal, particularly if allowances are allocated on the basis of intensity (per unit of output) rather than on an absolute basis. Such effects should be taken into account when setting the level of the BCA if, as is the case for the schemes proposed to date, the use of BCAs does not induce full auctioning of allowances.

*Encouraging emission-reduction efforts in developing countries.* Under most U.S. proposals, the carbon content of imported goods would be assessed using a nationwide average for the country of origin (Houser et al., 2008). Such calculations create little incentive for exporters to improve their emission intensity, as they would not be rewarded by lower adjustments at the importer's border. Assessing the carbon intensity at the level of a firm rather than a nation would avoid this problem, and yet would involve significant administrative efforts to measure, track, monitor and report emission levels. Furthermore, many industrial companies in non-carbon-constrained countries are the "best in class" technologically, using more environmentally friendly technology than other countries, thanks to their more recent industrial structure. Therefore, the tariff levied on an importing company may be low when emissions are calculated—the tariff could even be zero if the product uses electricity only and the electricity comes from a zero-carbon source. (This is notably the case for aluminum produced using hydroelectricity.)

Rather than being implemented as import taxes, BCAs could be implemented as export taxes by countries that have not implemented emission trading or carbon taxes, creating revenue for the exporting country while also contributing to creating a level playing field (Dröge, 2008). Nonetheless, if the tax is levied only on products destined for carbon-constrained countries, such schemes may have little leverage over developing countries' industrial activities. Indeed, in countries such as China, for example, only a small percentage of total domestic production is exported to the United States or the European Union (Houser et al., 2008; Reinaud 2008a). One answer to this challenge may be international cooperation on BCAs, which would expand their use to all countries that have signed an international agreement (Neuhoff & Ismer, 2008). However, as Neuhoff & Ismer state, such a regime "would not address leakage concerns that might result if countries that have signed up to international agreements put different emphasis on the role of carbon pricing in their climate policy mix, even if these countries may otherwise have pursued stringent climate policies."

*Administration costs.* The difficulty of implementing BCA systems should not be underestimated. The challenges will include measuring, monitoring and verifying imported-products emissions of foreign producers, setting an appropriate baseline of emissions and establishing "fair" GHG pricing. Another significantly political consideration is determining "comparability of efforts" from developing countries, which may or may not implement non-pricing climate policies to mitigate emissions, or which implement policies that only indirectly reduce carbon dioxide emissions (such as energy-efficiency policies).

The BCA approaches on the table today might not be suitable to fully address the leakage concerns of vulnerable sectors. While they are effective in addressing leakage concerns for importing, emission-intensive sectors, they are not appropriate for exporting sectors that are emission and electricity intensive. Therefore, complementary and more cooperative measures that engage specific sectors in developing countries may help address competitiveness and leakage concerns.

#### 4.1.2 *Embedded carbon product standards*

Embedded carbon product standards would effectively control market access. If their implementation involved a state organization in some way, they would almost certainly be ruled non-compliant under the WTO's provisions on technical barriers to trade. Given this issue, and the fact that standards of this type have not been seriously proposed by national or regional governments to date, we do not consider them further in this paper.

### 4.2 Alternative options

Domestic measures encompass the pursuit or introduction of free-allowance allocation or direct grants (such as state aid) to energy-intensive, trade-exposed manufacturing sectors. Only the allocation of free allowances is entrenched in existing legislation. Its impacts are very similar to those of other industrial support schemes.

#### 4.2.1 *Aid to industry*

Direct financial subsidies could notably take the form of recycling the revenue from auctioning allowances, but while this option has been discussed, no formal proposal has yet been suggested to address competitiveness concerns for trade-exposed industry. We do not consider aid to industry further.

#### 4.2.2 *Free allowances*

Governments implementing mandatory ETS currently directly or indirectly make a two-step decision:

1. Identifying free-allocation eligibility (who may receive the special provision).
2. Setting the distribution formula of allowances (the allocation mode and the amount of free allocation).

Free allocation is a method for compensating for extra carbon costs in production. We presented the economics of free allowances in Section 3.1. In theory, under an absolute cap on emissions, whether allowances are provided for free or auctioned, the value of carbon-emission allowances should be reflected in the prices of products whose producers' emissions are capped, since every unused carbon allowance has a market value (the so-called opportunity cost). Free allocation acts as a subsidy to existing facilities and hence tackles part of the competitiveness-driven leakage route. It may therefore cushion the cost impact of the carbon price and thereby influence the covered entity's competitiveness. To be effective in maintaining competitiveness as it was before the implementation of climate policy, free allocation would also need to cover indirect costs. If it did not, this instrument would only be effective in shielding emission-intensive facilities, and not electricity-intensive activities, from leakage.

Arguments against free allocation underscore that the approach limits incentives for innovation and distorts efficient investments. Yet whether or not free allocation encourages investments in research and development or in low-emitting carbon technologies will depend on the benchmark and cap that governments set. Indeed, governments could set a stringent benchmark for both incumbents and new entrants, forcing them to reduce their emission levels beyond a business-as-usual scenario. The benchmark could also be dynamic and become more stringent as technologies develop, lowering the cap over the long term.

Some have argued against free allocation with benchmarks by claiming it undermines the incentives to substitute carbon-intensive products with low-carbon-intensity products. This may be true if the mode of allocation is based on measured output. Such "ex-post allocation" would limit the carbon price signal in product prices, and would thus undermine the economic effectiveness of an ETS as a tool for internalizing climate change costs and push product substitution toward lower-carbon-intensity products. It would also reduce economic efficiency because it eliminates the option of reducing production to meet caps. The incentives to substitute products are not undermined as strongly if the emission cap for producers is fixed prior to the trading period.

The impact of granting free allowances is difficult to gauge. The impact assessment of the proposed EU climate change and energy package of January 2008 assessed the impacts on GDP of free allowances compared to auctioning. It found that allocating allowances for free reduces GDP growth in the period to 2020 by 0.5 per cent, or about 0.03% per year on average—a small amount compared with the total GDP growth projected for the same period, which is on the order of 2 per cent per year. Introducing auctioning into the EU ETS would reduce this to a total decrease of 0.35 per cent. The impact assessment stated that the results are dependent on how auction revenue is recycled, which affects GDP, employment and the distribution of income (Commission of the European Communities, 2008).

To conclude, the effectiveness of free allocation in limiting carbon leakage is uncertain and will depend on the benchmark and the cap used. Addressing loss of competitiveness and carbon leakage domestically in an effective manner will certainly require the implementation of a comprehensive policy portfolio, not only to ensure that the wide range of leakage concerns are effectively addressed in the short and long term, but also to provide a tailored solution that is suited to different sectors, which have different fundamental characteristics (such as electricity-intensive versus emission-intensive sectors). International agreements on industrial support through free allowances may be helpful but would not change the carbon price differences across jurisdictions.

### *4.2.3 Sectoral approaches*

As envisioned in current climate policy debates, sectoral approaches aim to broaden participation in the post-2012 climate regime (following the end of the first commitment period of the Kyoto Protocol) and encourage more climate-friendly practices in developing countries.[25] They are also intended to promote the transfer of these technologies and practices and to incentivize the pursuit of low-carbon research, investments and policies.

The precise design of sectoral actions under the UNFCCC is unclear at this stage, though there are three broad categories of possibilities: 1) domestically oriented approaches, often focused on developing countries, with or without GHG emission crediting or trading; 2) various approaches to

25 Approaching developing countries' engagement through sectoral approaches is nonetheless only one option (though a prominent one). For further discussions on options, see Philibert (2005).

technology cooperation and 3) sectoral, transnational agreements. These options overlap in a number of areas (Baron et al., 2007). They also vary in possible support (and type of support) and emission-reduction stringency. As defined in the Bali Action Plan, cooperative sectoral approaches "supported and enabled by financing and technology" could take multiple forms.

Whether these types of cooperative sectoral approaches could play a role in reducing carbon leakage is unclear. If a sectoral agreement takes the form of national, sectoral, legally binding targets in major economies, this could potentially address leakage. Nonetheless, as mentioned above, if countries use non-pricing policies (such as command-and-control or voluntary agreements), competitiveness loss and carbon leakage concerns will remain—essentially, industry within countries with a carbon cost will still face this cost, disadvantaging them against industry in countries without carbon costs. Furthermore, several countries have expressly rejected this option (see, for example, the submissions from China, India, the G77 and China, Indonesia, and South Korea to the UNFCCC in the Accra workshop on sectoral approaches).

**Table 4.1 Views on sectoral approaches from a selection of countries.**

| Country | Views |
|---|---|
| **G77 and China (represented by the Philippines)** | • Believe transnational sectoral agreements not acceptable<br>• Believe sectoral agreements at the international level should not be used to impose targets on developing countries<br>• Believe domestic sectoral efforts are *one* option in the toolbox for national mitigation actions<br>• Believe sectoral approaches not a basis to impose trade barriers, punitive trade measures, benchmarking or standards for developing countries |
| **India** | • Believes it is not feasible to define norms or standards<br>• Rejects verification of attainment of sectoral standards<br>• Supports cooperative R&D with concessional working of intellectual property rights<br>• Supports norms on certain products and practices (e.g. recycling)<br>• Supports voluntary energy-efficiency programmes |
| **China** | • Rejects the notion of targets or standards<br>• Believes the discussion on cooperative sectoral approaches and sector-specific actions should strictly concentrate on enhancing the implementation of Article 4 paragraph 1(c) of the convention (technology transfer)<br>• Believes capacity building, development and transfer of technologies, and financing should be major components (including via the carbon market)<br>• Supports financing capacity building, development and transfer of environmentally sound technologies, and restructuring of sectors |
| **Indonesia** | • Believes sectoral approaches not to be used for quantification of national targets; they complement rather than replace national strategies and mid-term goals<br>• Opposes applying uniform standard for developed and developing countries equally<br>• Supports sectoral approaches as analytical tool to inform national mitigation efforts and not as replacements for national targets<br>• Believes they should not lead to commitments for developing countries<br>• Believes they should not constitute a means for unjustifiable discrimination or disguised restriction of access of non–Annex I parties to international trade |
| **South Korea** | • Believes sectoral approaches should not "lead to commitments for non–Annex I Parties"<br>• Believes they should be measurable, reportable and verifiable<br>• Supports nationally appropriate mitigation actions that are credited through the carbon market |
| **Japan** | • Believes sectoral approaches should not replace national emissions-reduction targets<br>• Believes sectoral approaches should be consistent with the principle of "common but differentiated responsibilities and respective capabilities"<br>• Opposes applying a single common standard to all countries<br>• Opposes trade sanctions<br>• Supports crediting and support to nationally appropriate mitigation actions<br>• Believes benchmarking, on a sectoral basis, should be the method for setting quantified national emissions-reduction binding targets for developed countries (should these be agreed upon) |
| **European Union** | • Believes technology and policy cooperation should occur through sectoral approaches and incentives<br>• Supports approaches using carbon-market and incentives (national or international emissions trading on a sectoral basis, sectoral no-lose mechanisms and sectoral crediting mechanisms)<br>• Supports differentiated instruments and crediting according to countries' varying capabilities<br>• Believes sectoral approaches should not replace economy-wide reduction targets for developed countries |
| **Least developed countries (represented by Bangladesh)** | • Believes sectoral approaches are not a substitute for developed countries' targets<br>• Believes sector–specific, emission-efficient technology and best practices should be made available to least developed countries on a priority basis, along with commensurate financial flow<br>• Supports developing mechanisms for technology transfer where intellectual property rights issues are involved<br>• Supports creating a virtual technology and best-practices "bank" by sector, for ready access to information necessary for sectoral approaches |

***Note:*** Article 4.1 (c) of the Convention: "Promote and cooperate in the development, application and diffusion, including transfer of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors."

The design of domestic sectoral actions in developing countries also points to several options in terms of the type of support they would require and the extent to which they would be used. Some sectoral approaches consider widening the reach of the carbon market beyond the project-by-project approach adopted with the Clean Development Mechanism, in the form of a sectoral mechanism. This may, however, accentuate the loss of competitiveness for activities in developed countries if revenues accrue to competitors in heavily traded manufacturing sectors. Increased loss of competitiveness would also result if sectoral support projects granted a competitive advantage to a facility by lowering its production costs. Another hurdle is the possibility that a sectoral program could reward laggards by in fact subsidizing their GHG improvements, while others have taken such measures without financial incentives (Baron, Reinaud, Philibert & Genasci, 2007). Yet as it stands, the currently implemented Clean Development Mechanism does not appear to have enhanced the competitiveness of developing countries[26] (Reinaud 2008a). Furthermore, in the case of a sectoral mechanism, a stringent baseline for crediting could limit the subsidy effect to competitors, as could limitations on the number of credits that could be imported into Annex I carbon markets (such as the EU ETS).

As no proposals have been adopted by countries at the international level, it is difficult to understand how sectoral approaches will affect leakage rates. The effect will depend on the various types of support, including finance, that could be provided for a sector-specific approach, and how financing could be differentiated between domestically oriented sectors such as electricity and trade-exposed sectors such as iron and steel. Also, we could possibly differentiate, for example on the basis of company size, between those companies that have the independent financial and managerial capacity to upgrade their facilities with lower-emitting technologies and those that would need help from the international community. So far the UNFCCC and the Kyoto Protocol have taken a two-tiered approach to GHG mitigation, with emerging economies remaining unconstrained while developed countries are expected to take the lead. Differentiating the level of support within sectors to reflect the level of financial and technical capabilities of companies to reduce emissions would mean applying the "respective capability" clause of Article 3.1 of the UNFCCC to companies themselves.

Colombier and Neuhoff (2007) state that carving out sectors from international agreements so that firms in developed and developing countries face equal carbon costs is unlikely. They conclude that "where leakage concerns are strong, voluntary sectoral agreements are unlikely to succeed in addressing these."

## 4.3 Dealing with competitiveness and leakage concerns in practice

The experience of countries and regions that have implemented or are considering implementing emission trading schemes is highly instructive. This section first reviews the experience of the European Union, notably during the development of its proposals for Phase 3 of the EU ETS, which will run from 2013 to 2020. The issues and potential solutions have many common features globally, and the section also includes analysis of the proposals and debate in the United States and Australia.

26 Reinaud (2008a) states that little technology transfer has occurred to date and that it has not been possible to identify energy efficiency savings from Clean Development Mechanism projects.

#### 4.3.1 The European Union

The experience from the EU ETS in designing and implementing a scheme to deal with competitiveness concerns is extremely instructive regarding the uncertainty as to what the actual competitiveness and leakage impacts would be, how sectors can be differentiated on the basis of their exposure to carbon leakage, and how willing governments really are to impose significant carbon costs on their industries.

The EU ETS was designed to be phased in gradually, allowing for learning by doing and ensuring that major disruptions would not occur in the European Union's internal market. For the first two phases of the EU ETS (2005 to 2007 and 2008 to 2012, respectively), the European Commission decided that the vast majority of allowances should be allocated for free, on the basis of historical emissions.[27] Costs to regulated sectors were therefore related only to their deficits in emissions when compared to their caps. While discussed and studied, competitiveness and leakage issues did not achieve high prominence until the European Commission introduced its proposals for Phase 3 of the EU ETS, which will run from 2013 to 2020. The European Commission's January 2008 proposals included a major revision of several elements of the scheme, including a far larger role for auctioning. Those sectors not considered to be "exposed to a significant risk of carbon leakage" were expected to purchase all or most of their allowances from auctions from the start of the period; sectors considered to be exposed to a significant risk were allowed a phasing-in period before full auctioning beginning in 2020.

##### 4.3.1.1 The January 2008 proposals

In its January 2008 proposals, the commission suggested a three-step approach to determine which sectors (and subsectors) would receive what level of free allocation.

1. The first step would involve a quantitative analysis of sectors and subsectors at risk. It would assess the cost-increase impact—direct and indirect—and identify sectors' exposure to international trade. Based on this analysis, the commission would decide on the profit-neutral price increase needed (that is, in light of the sector's pass-through capacity, what levels of free allocation could allow companies to maintain their profit margins).
2. A second analysis would then refine the results found in step 1 based on a qualitative assessment of sectors' pass-through capacity. A certain number of other factors would be taken into account, such as transportation costs, tightness of the market, its geographical scope and concentration, and the value-chain structures. Following this stage of analysis, the categorization of sectors and subsectors based on their pass-through capacity would be reassessed.
3. Finally, in light of the international negotiations, the final decision would be made on which subsectors would receive what amount of free allocation (Communication from the Commission to the Council, 2007).

27 "Grandfathering" is used to assign current allowances using an algorithm based on past emissions.

#### *4.3.1.2 Debate on the January 2008 proposals*

The January 2008 proposals sparked a major debate. Regulated sectors were suddenly faced with the prospect of costs that were not covered by free allowances and began to lobby for a weakening of the proposals. The European Commission started to detail how sectors would be assessed for being "exposed to a significant risk of carbon leakage," and the academic and policy research community published studies on how the scheme could affect regulated sectors in practice.

The debate took place within the development of the European Union's strategy to reduce its emissions of GHGs in the post-2012 period. In order to enable the Energy and Climate Change Package to feed into COP-15 in Copenhagen in December 2009, the European Commission decided that the package should be completed before the end of 2008. The French Presidency of the Council of the European Union energetically ensured that this deadline was met, with the package finalized during the last days of COP-14 in Poznan (December 11 to 12, 2008) and approved by the European Parliament on December 17, 2008. The 11-month period between the European Commission's original proposals and the final compromise saw intense debate, with the final package markedly different from the original proposals. While the financial crisis, which began to unravel in earnest in October 2008, undoubtedly had an influence on the final compromise, the debate is an extremely useful case study for other countries and regions facing competitiveness and leakage concerns.

The European Parliament's proposed amendments were presented on October 5, 2008 (Doyle, 2008). Taking into account these amendments, the European Commission's original proposals and the wide range of formal and informal representations it received during 2008, the European Council reached agreement on its energy and climate change package on December 11 and 12, 2008.[28] The European Parliament approved, with revisions, the European Council's proposals on December 17, 2008 (European Parliament, 2008b).

The final package continued to address the impact of competitiveness and leakage by granting free allowances to activities, sectors and subsectors considered to be at risk. It included details on how the assessment of "at risk" should be conducted. It retained the option of amending provisions if an international agreement was concluded, but brought the date for this decision forward and added further potential provisions.

#### *4.3.1.3 Final decisions on allocation*

The European Commission maintained that auctioning of allowances should remain the preferred basis for allocation; however, the final compromise saw a significantly higher proportion of free allowances compared with auctioning than the proposals of January 23, 2008. Harmonized rules for allocation would be applied to installations, wherever they were within the European Union.

28 See paragraph 20 of European Council (2008), which refers to the "points contained in 17215/08," that is, in General Secretariat of the Council (2008).

**Table 4.2** **Proposed allocations under the European Community's proposals of January 23, 2008, and December 12, 2008.**

| Sector allocation | Proposal, January 23, 2008 | Final energy and climate package, December 12, 2008 |
|---|---|---|
| Electricity generation, carbon capture and storage | 100% auctioning from 2013** | 100% from 2013 in electricity generation, but with a derogation of at least 30%, rising linearly to 100% in 2020 for certain member states***<br>100% auctioning for carbon capture and storage |
| Sectors "at significant risk of carbon leakage"* | Will receive up to 100% of their allowances for free in 2013–2020 | 100% free allowances "to the extent that they use the most efficient technology" |
| Sectors not "at significant risk of carbon leakage"* | 20% auctioning 2013, linear increase to 100% in 2020 | 20% auctioning 2013, linear increase to 70% in 2020 with a view to reaching 100% by 2027 |

*Sectors that could be forced by international competitive pressures to relocate production to countries outside the European Union that do not impose comparable constraints on emissions. This would simply increase global emissions without any environmental benefit.
**Takes account of the sector's ability to pass on the increased cost of emission allowances.
***Member states that "fulfil conditions relating to their interconnectivity or their share of fossil fuels in electricity production and GDP per capita in relation to the EU-27 average, have the option to temporarily deviate from this rule with respect to existing power plants" (European Parliament, 2008). The provision refers to new member states in the east of the European Union. They are required to submit national plans showing how the value of their free allocations will be spent on retrofitting and upgrading infrastructure and clean technologies (submitting an annual report detailing investments) and diversifying their energy mix.

A number of subsidiary conditions were attached to allocation. Of key import was the requirement that the total number of allowances allocated for free to installations decline annually in line with the decline of emission caps. Given that the EU ETS will see a reduction of 1.74 per cent of the original number of allowances in the periods from 2013 to 2020 and 2021 to 2028, with a review by 2025 at the latest, even those sectors or subsectors continuing to receive free allocations will see the number decline over time.

The final agreement included a set of internal redistributive conditions, with 12 per cent of allowances redistributed, effectively, from the member states with the highest GDP per capita to those with the lowest.

The agreement also included the possibility of financial compensation for indirect emissions. Article 16a6 of the revised directive provides for the possibility for member states to compensate, through national state aid schemes, the most electricity-intensive sectors for increases in electricity costs resulting from the ETS. Therefore, the commission will correspondingly modify the environmental state aid guidelines by December 31, 2010.

Finally, the provision that 20 per cent of the revenues raised from auctioning should be used in the fight against and adaptation to climate change was increased to a recommendation of at least 50 per cent, and the agreement specified that "part of this amount will be used to enable and finance actions to mitigate and adapt to climate change in developing countries that will have ratified this [international] agreement, in particular in least developed countries."

#### 4.3.1.4 *Final details on assessing activities, sectors and subsectors "at significant risk of carbon leakage"*

We quote the following from General Secretariat of the Council (2008, emphasis added):

> A sector or sub-sector is deemed to be at a significant risk of carbon leakage if the *sum of direct and indirect additional costs induced by the implementation of the Directive would lead to an increase in production costs exceeding 5% of Gross Value Added and if the total value of its exports and imports divided by the total value of its turnover and imports exceeds 10%.*
>
> By way of derogation, a sector or sub-sector is also deemed to be exposed to a significant risk of carbon leakage *if the sum of the direct and indirect additional costs induced by the implementation of the Directive would lead to an increase in production costs exceeding 30% of its Gross Value Added or if the total value of its exports and imports divided by the total value of its turnover and imports exceeds 30%.*

Further sectors or sub-sectors deemed to be exposed to a significant risk of carbon leakage may be added after the completion of a qualitative assessment

taking into account, when the relevant data are available, the following criteria:

- the extent to which it is possible for individual installations in the sector and/or sub-sector concerned to reduce emission levels or electricity consumption, including, as appropriate, the increase in costs of production that related investment may entail, for instance on the basis of the most efficient techniques;
- market characteristics (current and projected), including when trade exposure or direct and indirect cost increase rates are close to one of the thresholds mentioned [when non-EU trade intensity is above 10 per cent];
- profit margins as potential indicator of long-run investment and/or relocation decisions.

The document advises that the starting point for the definition of a sector should be the NACE-3 code,[29] but that NACE-4 codes should be used "where appropriate and where the relevant data are available."

The European Commission has not produced a list of which sectors and subsectors it deems to be at significant risk of carbon leakage. The conditions quoted above are wide-ranging and include several subjective elements—developing the final list will likely include some political bargaining.

#### 4.3.1.5 *Taking account of an international agreement or comparable commitments in third countries*

The European Commission continued to make final decisions conditional on the outcome of the international agreements. The proposed amendments to Article 10a of the amended directive now include the provision, under paragraph 9d, that the list of sectors or subsectors exposed to a significant

29 The European Commission's Nomenclature of Economic Activities.

risk of carbon leakage be determined after taking into account "the extent to which third countries[30], representing a decisive share of world production of products in sectors deemed to be at risk of carbon leakage, firmly commit to reducing GHG emissions...and the extent to which carbon efficiency of installations located in these countries is comparable to that of the EU." The amendments include the proviso that the determination is conditional on the availability of the relevant data. The agreement brought forward the dates for when assessments will be made to:

- No later than December 31, 2009, and every five years thereafter for the assessment of which sectors or subsectors are at risk.
- No later than June 30, 2010, for decisions relating to the outcome of international agreements.

Three further conditions were added that depend on the outcome of international agreements:

1. The commission will study the possibility of granting additional allowances free of charge to industrial sectors exposed to a significant risk of carbon leakage (based on a proposal to the Commission to the European Parliament and Council expected in June 2010).
2. "In its impact assessment of the negotiations of an international climate change agreement, the Commission will take account of the impact of carbon leakage on Member States' energy security, in particular where the electricity connections with the rest of the European Union are insufficient and where there are electricity connections with third countries. The Commission may take appropriate measures in this regard."
3. The option of applying border measures was added to the possible actions for redress (which were previously the granting of free allowances and including product importers within the ETS).

In common with allocation, the net effect of these conditions has been to add some uncertainty to the questions of which sectors and subsectors will receive free allocations and how the quantity they receive may change with time.

#### *4.3.1.6 French importers*

French importers could also surrender some of their own allowances for goods that they import from developed countries that do not have comparable emission-reduction commitments or from developing countries that do not contribute adequately to mitigation efforts (Reinaud, 2008a).

### *4.3.2 The United States*

In the United States, House Resolution 2454, the American Clean Energy and Security Act of 2009 (hereinafter the Waxman-Markey bill) has also seen a move toward granting free allowances as a response to competitiveness and leakage concerns as it has moved through its consultation phase.

30 Countries outside the European Union.

The proposals within the May 15 draft include absolute caps for industrial sectors, but allow for the output-based rebate of costs associated with direct emissions (85 per cent of costs) and indirect emissions (100 per cent of costs) to those sectors considered "vulnerable" to competitiveness and leakage impacts. In economic terms, these firms effectively face an intensity-based cap, with their effective carbon cost reduced from the market carbon price by the rebates. They face a very weak incentive to reduce their GHG emissions.

Vulnerability is defined using a mixed use of the trade-intensity and GHG/energy-intensity indicators. An industry is vulnerable, and thus eligible to receive free allocation of allowances, if:

- It has an energy intensity or GHG intensity of at least 5 per cent and a trade intensity of at least 15 per cent or
- It has an energy or GHG intensity of at least 20 per cent (H.R. 2454, 2009, Sect. 764).

In common with the EU ETS, a review of the provisions relating to competitiveness and leakage is planned. The May 15, 2009, version of the bill provided that by 2022, and after establishing that some sectors are vulnerable in spite of the rebate scheme, the president must choose to modify the rebate phase-out, implement a BCA or both. Beginning in 2025, if a BCA is chosen, the program administrator will establish a price for allowances that reflects the difference between the direct and indirect costs that the U.S. sectors must bear under the act and the direct and indirect costs of GHG reduction policies that foreign governments impose on their sectors. The administrator must factor in the impacts of free allocation in the United States. The draft contains a provision that foreign countries would only need to impose 60 per cent of the costs felt by U.S. producers. This would require the administrator to make calculations for all countries, across all their PAMs. There is of course a risk that such difficult and complex calculations, performed unilaterally and in the absence of multilaterally defined principles or methodologies, have the potential to be politically influenced.

As the Waxman-Markey bill has progressed through the U.S. House and Senate, options to respond to competitiveness and leakage have been strengthened. Congressman Sander Levin's proposal of June 25, 2009 (Levin, 2009), based on an agreement between him and Henry A. Waxman, chair of the Energy and Commerce Committee, changed the burden of proof. Under his amendment, the president "shall impose a border adjustment to address uncompensated increases in costs for all industries receiving free allowances unless he determines it is not in the national interest and Congress passes a privileged resolution agreeing with that determination." Additionally, the date for the assessment has been moved forward, with border adjustment required by 2020.

#### *4.3.3 Australia*

In Australia the government released a draft ETS proposal indicating several design options and the government's preferred position. Regarding allocation, the preferred position is that all industries other than those for which a physical barrier to trade exists be considered for assistance. This is based on the idea that all tradable industries are somewhat limited in their ability to pass through cost increases, at least over the medium term. The level of assistance could be determined based on trade exposure and the exposure to competitiveness loss. Exposure to loss of competitiveness would be based on the selection of one of the following criteria: employment, value added and the value of production or revenue. An effective international agreement would nonetheless remove the need to provide transitional assistance. For indirect cost increases, allowances can be distributed following a defined benchmark (such as per tonne of carbon dioxide emitted or per megawatt-hour purchased), either predetermined based on historical consumption levels or adjusted prior to the trading period.[31]

31 In Australia, allocation of assistance for indirect electricity emissions of new and existing emissions-intensive, trade-exposed (EITE) entities would be calculated "on the basis of an Australian historical industry-average electricity-intensity baseline for each EITE activity; an electricity factor, where the electricity factor is determined to reflect the likely average electricity price impact of the scheme; the output of the EITE activity for each entity [only adjusted to the lower side—that is, if the output is above the cap, companies would not receive more allowances]; the assistance rate for that EITE activity. The government would also take into account whether the EITE entity has contractual arrangements with regard to electricity supply that would shield them from increases in electricity prices as a result of the introduction of the scheme" (Australian Department of Climate Change, 2008).

# 5.0 Effectiveness of options—economic and environmental

Section 3.3.3 summarized leakage results from PEMs, concluding that for the sectors considered at risk of competitiveness loss and leakage, leakage rates were variable and were always under 100 per cent.

GEMs simulate how the economy as a whole would react to policies and responses to them, importantly including more channels of leakage; for example, the fossil fuel–price channel, whereby carbon constraints in one country lower the fossil fuel price in others, thereby increasing demand and GHG emissions.

Demailly and Quirion (2006) state that their use of a PEM does not "account for pre-existing distortions or macro-economic feedbacks—on world energy prices for example." Braathen (2008, as reported in Reinaud, 2008b) notes that leakage related to the loss of competitiveness of individual sectors is small compared to that triggered by changes in international fossil fuel prices, when quantified in a general equilibrium setting. The authors note that "findings indicate that the most important leakage normally would stem from the fossil fuel markets."

General equilibrium analyses cast doubt over the effectiveness of border adjustments for offsetting competitiveness and leakage.[32] Our review of studies undertaken for the OECD Roundtable on Sustainable Development on Competitiveness and Leakage in Singapore in July 2009[33] (see Table 5.1) suggests that based on what BCAs can achieve, they may be useful for managing the domestic distributional effects of climate policy, but are likely to be less useful for minimizing the overall costs of climate policy or reducing leakage.

32 We are not aware of any GEMs that explicitly consider the use of free allowances to reduce competitiveness and leakage impacts.

33 The roundtable produced two background papers. Stephenson and Upton (2009) focuses on politics and fiscal policy; Wooders et al. (2009) focus on economics and technical aspects. The review of the GEM work was conducted primarily by John Stephenson of the OECD.

Table 5.1 Economy-wide and international effects of BCA.

| | Coalition implementing BTA | Preservation of industry competitiveness | Coalition welfare | Global welfare | Leakage reduction |
|---|---|---|---|---|---|
| **Alexeeva-Talebi, Anger and Löschel(2008a)** | EU | Partial | Reduced | — | Modest |
| **Babiker and Rutherford (2005)[1]** | Annex I (excludes U.S.) | Partial | Improves in EU Reduced in some OECD countries | Reduced | Modest |
| **Burniaux, Château, Duval and Jamet (2008)** | EU | No | Reduced | Reduced | Substantial |
| **Burniaux et al. (2008)** | Annex I (includes U.S.) | — | Reduced | Reduced | Moderate |
| **U.S. Environmental Protection Agency (2008)** | U.S. | Partial | Reduced | — | Negligible |
| **Manders and Veenendaal (2008)** | EU | Partial | Improved | — | Substantial |
| **McKibbin and Wilcoxen (2009)[2]** | U.S. | Partial | Unchanged | Reduced | Substantial |
| **Peterson and Schleich (2007)** | EU | Partial | — | — | Modest |

1 Scenario with flexible wage and access to Kyoto flexibility mechanisms.
2 Scenario based on a U.S. carbon tax and BTA.

For a full review and discussion of general equilibrium analyses, see Stephenson and Upton (2009) and Wooders, Cosbey & Stephenson (2009).

## 5.1 Measuring embedded carbon

How effective the various options will be in reducing competitiveness and leakage impacts depends on the differences in GHG emissions among like products from different sources and on the options producers have to reduce these emissions. In turn, this depends on whether embedded carbon can be measured.

All options designed to respond to competitiveness and leakage concerns must assess the embedded carbon content of products. The level of precision required is higher for BCAs, where a producer-specific figure could be needed to comply with WTO rules (see Section 6.1).

While it may appear simple at first glance, measuring the carbon content of a product presents difficulties that should not be underestimated.[34] The three main issues are:

1. *A number of assumptions are required—there is no "right" answer*. What assumptions are made can lead to major differences in the calculation of embedded carbon from a single set of data. The assumptions need to:
    a. Define the boundaries of the system. For example, should it include the GHG emissions embedded within inputs of raw materials? Embedded within plants and machinery? From transport of the product to its markets?
    b. State how emissions from electricity should be included. Options include a marginal or an average basis, as well as whether emissions should be calculated on the basis of the grid average, associated with a specific plant or using some other measure.
    c. Define a protocol that can be used worldwide in a non-discriminatory manner.
2. *The data required is not available, particularly to the quality required*. This is particularly the case when consistent data covering both financial and physical factors is needed. In many countries, there are major gaps in the data that would be required. This is a concern even before we consider the stepwise change in data quality needed to allow a financial charge to be associated with an analysis using such data. Data quality would need to stand up to legal review. A challenge would focus on whether data had been collected to an agreed protocol, had met quality assurance procedures and had been audited by an independent organization.
3. *Developing and maintaining the capacity to collect data from all affected producers, to an agreed protocol, would require significant resources*. Therefore, countries may object to any requirement to provide these resources on the basis that these represent a restraint on trade.

There are precedents we can learn from. The concept of "embedded ozone" was researched under the Montreal Protocol, but the negotiators finally decided not to use it. Most environmental consultancies

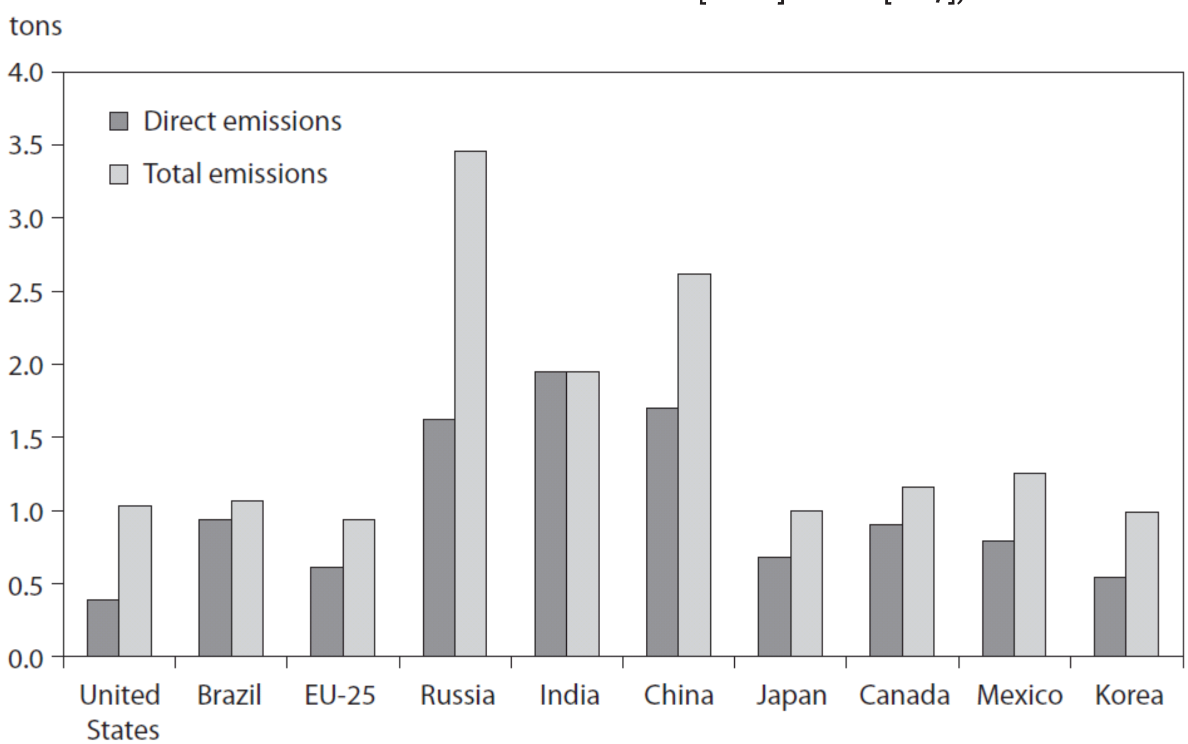
34 For a full background on embedded carbon, see Kejun, Cosbey and Murphy (2008).

now have dedicated life-cycle assessment[35] teams active in assessing the carbon content of specific products or processes. These assessments are much more limited in nature than what would be required under a BCA agreement, yet require teams of professional staff. Industries themselves are collecting the necessary data. Thus the Cement Sustainability Initiative (www.wbcsdcement.org), a working group of the World Business Council for Sustainable Development, has a database titled Getting the Numbers Right. This database collects defined physical statistics (excluding financial statistics) on each plant of each of its members. It is maintained by PriceWaterhouseCoopers. Reporting of data is strictly controlled, since its release may provide commercially confidential information; this is another issue that must be taken into account when deciding what data to collect and who will hold it.

### 5.1.1 *Average figures*

Studies on competitiveness and leakage tend to use aggregated estimates of the GHG emissions resulting from the production of products such as cement and steel. An example is the carbon intensity of steel by country or region. Data from International Iron and Steel Institute (2006a) and the IEA (2007) shows that total emissions from U.S. steel production are, on average, 40 per cent of those from Chinese steel production. A major part of the difference is due to the much higher share that plants that recycle steel play in the United States compared with China. These plants require electricity to melt the recycled scrap, a far less energy- and GHG-intensive process than steel production that starts with iron ore in a blast furnace.

**Figure 5.1** **Carbon intensity of steel, 2005. Reprinted from Houser et al. (2008, p. 47, created with data from the International Iron and Steel Institute [2006a] and IEA [2007]).**




35 The equivalent of production processes and methods in trade terms.

### 5.1.2 *Drivers of product carbon content*

The example given above showed that the comparison of average GHG emissions from steel production requires an understanding of the relative rates of use of scrap steel. For steel, the process employed is an important determinant of product carbon content. Generically, drivers of product content include:

- Process
- Management of the process
- Energy-efficiency equipment and techniques employed
- Mix of fuels used: coal, gas, oil, biomass, wastes, electricity
- Source(s) of the electricity consumed[36]
- The extent to which recycled materials can be integrated into the process or into the product
- The extent to which blends can be added to the product of the primary process, effectively requiring less primary product per unit of final product[37]

The relative importance of these drivers depends on the product. Table 5.2 summarizes the drivers for cement, steel and aluminum. All three processes are relatively mature; the difference between the best-managed facilities with high levels of energy efficiency and the lowest-performing facilities is generally under 10 per cent.

36 Is it really possible to define the provenance of electricity? Where the plant is tied through a physical connection, the case is relatively simple. Even here, the electricity that such a plant generates would find ready customers elsewhere, given that plants such as hydro and nuclear are capital intensive but have low operating costs and low GHG emissions. Then there is the question of whether customers paying premiums for hydroelectricity or some other source would alter the generating mix in the long term.

37 Perhaps the key example is the addition of fly ash, ground granulated blast-furnace slag and other pozzolans to clinker (the output of the primary cement process) in order to increase the quantity of final cement per unit of clinker produced. Such blending is one of the most important options cement manufacturers have for reducing their GHG emissions.

Table 5.2 **Drivers of product carbon content in cement, steel and aluminium. Footnotes show sources.**

| Product | Process | Fuel mix | Electricity source(s) | Use of scrap | Blending |
|---|---|---|---|---|---|
| Cement | All cement processes use kilns. The dry kiln is the most energy efficient and is now the technology of choice around the world, except when the limestone available is wet, when a process that is at least partly wet is used. | Where coal is available, it tends to dominate. Gas use is common in parts of eastern Europe and the Middle East. Biomass and waste use can save costs and reduce GHG emissions. | Not process dependent. Waste-heat recovery can generate a relatively small amount of electricity and is the industry standard in many countries. | Not currently possible.[1] | Average rate worldwide 10%. Rates of 30% and higher possible.[2] |
| Steel | Iron-ore reduction in the blast furnace is the key primary route, with basic oxygen smelters then used for steel production. This "direct reduced iron" allows the construction of smaller, simpler plants. The "sponge iron" from direct reduced iron is then refined in an electric arc furnace. Electric arc furnaces also refine scrap steel. | Substituting coal and natural gas in the blast furnace lowers costs and emissions. There is little current potential to use biomass or waste. | On-site generation is typical, often using gases from the coke oven and blast furnace. | The scrap metal market is large and growing, and includes internationa l trade. Primary and secondary production are largely separate.[3] | Not strictly possible. Different types of steel can lead to the reduction of steel needed in products.[4] |
| Aluminum | The primary process is electrolysis of aluminum-oxide ore. Recycling of scrap occurs either within remelters (clean scrap only) or refineries (all grades). The process is essentially fixed, with various proprietary secrets. | Fuel use is negligible compared electricity and is not part of the primary production process. | Source of electricity is the key cost driver. Plants tend to be built with dedicated power plants, often hydroelectric | The majority of aluminum is now recycled.[5] | Not strictly possible. Different types of aluminum can lead to the reduction of aluminum needed in products.[6] |

[1] The Cement Sustainability Initiative is one of several organizations investigating this possibility.
[2] The rate possible depends predominantly on whether blending materials are available, whether blends are allowed under national legislation and whether consumers will accept blended cements. The cement industry has varying influence over these issues.
[3] It is possible to introduce a limited amount of scrap into the basic oxygen furnace associated with the blast-furnace route. Electric arc furnaces can use 100% scrap.
[4] For example, the use of advanced, high-strength steels in cars (see the World Steel Association website at http://www.worldsteel.org/index.php?action=publicationdetail&id=87)
[5] See the International Aluminum Institute's Recycling page at http://www.world-aluminium.org/Sustainability/Recycling
[6] See the International Aluminum Institute's Sustainability page at http://www.world-aluminium.org/Sustainability

Drivers of product carbon content, and the consequent range of carbon contents of products, are important for two main reasons:

1. The use of "best available technology" can be used in certain free allowance and BCA schemes.
2. An understanding of whether there are typical differences between national product carbon contents also informs scheme design.

Table 5.3 shows an analysis of these factors. The analysis in the table concludes that the ranges of emissions from steel and aluminum production are extremely wide, with the key factor being whether the route is a primary one (starting with the metal ore) or whether scrap material can be used. For cement, a best technology is more easily identified, as there is no secondary route, but the difference between the lowest and highest figures is much less extreme—though the emissions still more than double between the low and high ends of the range.

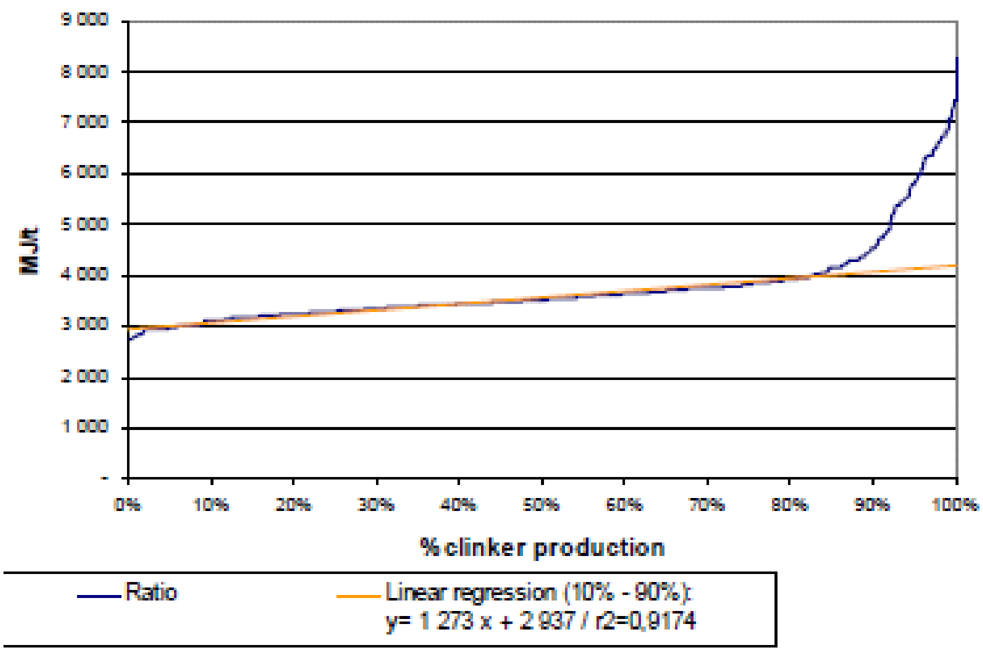
**Table 5.3** **Ranges of embedded GHG emissions, best technology and national characteristics for three key products.**

| Product | Emissions range (tonnes $CO_2$/tonne product) | Best technology | National characteristics |
|---|---|---|---|
| Cement | Range from 0.5 to 1.2 $tCO_2$/t cement, The calcination of limestone feedstock produces a fixed 0.53 $tCO_2$/t clinker; dry kilns in the EU (at or near best practice) add a further 0.35 $tCO_2$/t clinker[1]. Wet and semi-dry kiln processes add approximately 25% energy demand, shaft kilns (a smaller plant unique to China) a further 25%. Average addition of gypsum and blending materials is of the order of 20% of final cement, giving an EU average of 0.67 $tCO_2$/t cement. Higher blend rates and use of biomass and wastes can reduce this figure to around **0.5 $tCO_2$/t**. High end of the range approximately **1.2 $tCO_2$/t** cement. | Dry kiln with pre-calciner and 6-stage preheater. Blending of product and use of waste fuels and biomass. Use of natural gas could be specified but is considered uneconomical in many countries. | High-efficiency dry kilns are now the standard for new plants, except when the limestone feedstock is wet. China is responsible for 50% of world cement production and has a policy to close its smaller, low-efficiency "shaft" plants. An important national difference is the use of natural gas in parts of eastern Europe and the Middle East |
| Steel | Range from close to zero to 3.5 $tCO_2$/t steel. Best-in-practice blast-furnace route has direct emissions on the order of 1.6 $tCO_2$/t steel. Electricity requirement of 4 MWh/t steel adds 0–0.4 $tCO_2$/t steel. Older, less-efficient systems can result in emissions up to twice this amount or more. Electric arc furnaces using scrap require 6–10 MWh/t steel, giving emissions of 0–1.0 $tCO_2$/t steel depending on the electricity source. A route using direct reduced iron and an electric arc furnace, using natural gas reduction, typically has emissions close to that using a good blast furnace, again dependent on electricity source. | Electric arc furnace using scrap metal, with electricity supply from low-carbon source. But there will still be the need to use the blast-furnace route or an alternative, such as direct reduced iron, for introducing new steel into the system. | The use of scrap steel in electric arc furnaces has brought down average energy use and GHG emissions. Scrap usage rates vary around the world, and there is an international market for scrap. Older plants, often under national ownership, can have much higher emissions than newer plants and are prevalent in many parts of the developing world. |
| Aluminium | Range from 0 to 18 $tCO_2$/t aluminum. For the primary process, emissions from anode use and of PFCs (a potent GHG) are the equivalent of approximately 2.6 $tCO_2$/tonne. Average electricity use is 15.3 MWh/t. With coal-fired electricity, this would make aluminum responsible for emissions of 15.3 $tCO_2$/t. Secondary aluminum is 5% of this figure, i.e. 0.75 $tCO_2$/t, with negligible direct emissions. | Secondary aluminum production has 5% the electricity consumption of primary production. If hydroelectricity is used, emissions are close to zero. The need remains for a primary aluminum route for introducing new aluminum into the system. | Energy efficiency is highest for most modern plants, which can be anywhere in the world. A key issue is the source of the electricity, which does tend to have a national characteristic, notably whether the country has large hydroelectric plant or not. |

[1] Matthes et al., 2009.

Regarding national characterization, the only link between GHG emissions factor for aluminum and the country in which the aluminum is produced is how electricity is generated (notably whether a country has large hydroelectric plant). For steel, the share of production from scrap is a very important determinant, and average relative emission factors can be characterized to some extent at the national level. As ever, many countries, notably those in the developing world, can have a mix of best-of-class modern plants with inefficient older plants. There is also some possibility for national characterization of cement, notably with regard to the fuels used to fire kilns and the amount of blending in the final product. Again, countries can have mixes of technologies, with China (responsible for 50 per cent of world production) combining the most modern plants with aged, small "shaft" kilns and a number of wet kilns. The amount of thermal energy consumed per tonne of clinker production in different countries varies widely. This is only one driver of the final variability of emissions from cement production, whose calculation also needs to take account of the fuel mix used and the share of blending materials in the final product.

**Figure 5.2** **Primary-process cement efficiency in world plants in the Cement Sustainability Initiative's Getting the Numbers Right Database. Reprinted from Matthes, Repenning, Worrell, Phylipsen and Müller (2009).**



### 5.1.3 Tools to measure product carbon content

The quality and disaggregation of data required for studies that simulate policies is much lower than what would be required to support some of the options for addressing competitiveness and leakage concerns. An embedded-carbon product standard that imposed a maximum carbon content on imports would demand the highest level of data quality, since it would effectively decide access to a market. Faced with the prospect of being denied access, producers would be likely to consider legal action, which could involve a thorough review of data-collection processes and procedures.[38]

Tools, techniques and protocols to measure the carbon content of products exist. This fact neither implies that complete data sets exist nor that collecting such data would be quick or cheap. Measuring carbon content requires the definition of the product or products from an industry; a specification of the boundary of the process, including how far up and down the supply chain the process should go; and decisions on accounting principles, notably whether average emission factors for electricity supply can be used or whether marginal emission factors[39] are required.

The experience of the Cement Sustainability Initiative, a voluntary grouping of cement producers that currently includes 18 companies responsible for 30 per cent of world cement production, in setting up their Getting the Numbers Right database is instructive. The group rapidly decided that plant-level data was essential. They collected only physical, current data for these plants, excluding financial data or any future projections. The administrative management of the database was contracted out to a professional services company.

The Cement Sustainability Initiative data was collected to allow cement companies to understand their relative GHG emissions and to provide the basis for schemes such as exploring a new CDM methodology and investigating sectoral approaches for the cement sector. It uses a variant of the World Business Council for Sustainable Development/World Resources Institute GHG Protocol, the accepted protocol for measuring GHG emissions under International Organization for Standardization (ISO) standards.[40] The costs of developing and maintaining the database are met by the companies themselves on a voluntary basis.

Carbon footprinting and life-cycle assessment is a developed, growing business offered by environmental and other consultancies. Experience to date has focused on a limited range of products (such as the carbon labels produced for retailers such as Tesco in the United Kingdom) and on producing inventories of total emissions for companies that wish to set or make claims about GHG emission targets for themselves.[41] Giving an exact cost for the carbon footprint of a GHG-intensive process is difficult; Tesco's experience in producing carbon labels for over 200 of their products has

38 See Section 3.1 for detail on the legal issues associated with carbon product standards and other options to reduce competitiveness and leakage impacts.

39 The concept of the "marginal" generator is widely used in power-generation analysis. If demand for electricity increases or decreases, then the marginal generator is the specific electricity plant whose output increases or decreases. Its emission factor per unit of electricity generated will almost certainly be very different from the average of all generators within the system.

40 The ISO standard (14060 has been used since 2001; see also 14064 and 14065 for GHG quantification and reporting) identifies four main steps when conducting a life-cycle analysis: the first two steps (goal and scope development and inventory analysis) apply to calculating embodied carbon; the two later steps (impact assessment and interpretation of results) do not.

41 See, for example, Eurostar (2009).

required a contract with the environmental consultancy firm Environmental Resources Management over a 2-year period.[42] The work is based on measuring a set of inputs and outputs—such as electricity consumption in particular countries, transport miles driven by vehicle type, and quantities of steel and concrete used in construction—and then looking up the life-cycle emissions associated with these within a specialized database.[43] The database is populated with data from academic and research studies. The emission factors it contains have uncertainty ranges and, depending on the source, differentiate among different technologies and production processes. Certain assumptions must be made, for example, about the electricity-generating mix in a particular country. For electricity-intensive processes, the choice made at this point can fundamentally alter the emission factor of the particular product.

In order to calculate free allowance allocations based on benchmarking, government collaboration with industry is the usual way to develop the necessary databases. At least within developed countries, certain data already exists (for example, companies tend to report their fuel consumption to government statistics departments). Other data are collected for energy-efficiency best-practice programs and other government-led initiatives. The European Union's experience appears relevant: in order to establish which sectors they consider to be at "serious risk of leakage," they are working with industry to collect data sets at the subsector level.[44]

Measuring the carbon content of products to be covered by a BCA requires more detailed data, particularly if the BCA would be in the form of a carbon standard. The Cement Sustainability Initiative's experience of collecting plant-by-plant data is highly relevant. The development of the initiative's database took several years and included agreement on protocols and making decisions about "grey" areas (for example, emission factors for fuels derived from wastes and whether on-site electricity generation should be included within the system boundary). The development occurred within a self-selected group of volunteers; development could be slowed if it were less cooperative.

BCAs present a trade-off between accuracy and effectiveness versus administrative cost. Thus, an exercise that established the GHGs emitted from processes employing the best available technology and applied this to all producers would eliminate the need for estimating the GHG emissions from individual plants. Ismer and Neuhoff (2004) advocate such an approach, claiming also that it would be likely to comply with WTO rules.[45] It would clearly lead to an underestimate of GHG emissions for almost all plants and would also eliminate the incentive of firms to abate GHG emissions from their processes, since they could not reduce their emissions below those possible using the best available technology. It would be effective only as a trade measure. The analysis presented above, notably in Table 5.3, shows both that identifying a best available technology is not always straightforward and that the range of GHG emission factors can be very wide.

42 Environmental Resources Management's work is referenced as a case study on their website (http://www.erm.com/Analysis-and-Insight/Case-Studies/Case-Study-Tesco). Tesco's carbon-labelling initiative is described in their Carbon Labelling and Tesco document, downloadable from their web pages on Greener Living (http://www.tesco.com/greenerliving/cutting_carbon_footprints/carbon_labelling.page, accessed June 24, 2009).

43 For example, the Swiss "Ecoinvent" database (http://www.ecoinvent.ch).

44 See the European Commission's Carbon Leakage page at http://ec.europa.eu/environment/climat/emission/carbon_en.htm.

45 See Section 6 for a full discussion of WTO/GATT legality.

## 5.2 What is the most effective option?

Table 5.4 summarizes the effectiveness of free allowances and BCA implemented as a BTA. It concludes that BTAs are more likely to reduce competitiveness and leakage losses in the controlled sectors, but that much of these gains would be offset by changes in the wider economy.

**Table 5.4 Effectiveness of free allowances and BTAs under absolute GHG caps. "Effectiveness" is a principally a measure of how much competitiveness loss and leakage can be reduced. It also includes the notion of cost effectiveness.**

| | Free allowances | Border tax adjustment |
|---|---|---|
| **Empirical evidence** | No clear evidence of competitiveness impacts or leakage. Based on limited analysis to date, on a very limited data set (the EU ETS over a short time period, with high levels of free allowances granted). | None as yet. |
| **Economic theory—sectoral impacts** | Effectiveness likely to be low. In the *short term,* whether allowances are auctioned or granted for free should have no impact on firms' production decisions (the opportunity cost of the allowance value will be factored in for all cases). In the *longer term,* how free allowances affect firms' location choices is unclea—the expectation of future free allowances may provide some incentive to build new plants in carbon-constrained regions. Will be more effective if indirect cost increases (e.g., from purchased electricity) are also included. | Likely to be more effective than free allowances, as it directly addresses the carbon cost differential. To be fully effective, would require both the inclusion of indirect cost increases (e.g., from purchased electricity) and adjustments for the full range of climate change policies and measures applied by every country. Even if fully effective, product price increases would be expected to lead to falls in demand and profit of carbon-intensive products. |
| **Economic theory—macroeconomic impacts** | Granting free allowances represents a lost opportunity to the economy, and thus has a cost. It is also likely to delay the restructuring of the economy away from carbon-intensive industries. Economic theory suggests that free allowances will reduce economic output when compared to auctioning. | Adjustments in the macro economy will tend to offset effectiveness, potentially significantly. Of note is the fossil fuel price channel, whereby carbon constraints in one country lower world prices for fossil fuels, increasing demand and GHG emissions. Among other economic adjustments are terms of trade effects, whereby relative price changes act to erode competitiveness advantages, and a tendency for cost reductions in industries covered by BTAs to be associated with cost increases in other sectors of the economy. Imposing BTAs is predicted to reduce economic output, both in and outside the region applying the BTA. |
| **Model simulations** | Published studies show that differential carbon prices could lead to leakage rates typically in the range of 0–70%. These studies are based on the EU ETS and generally cover a single sector of the economy only (typically cement, iron and steel, or aluminum), without considering interactions with the wider economy. How effective free allowances are in reducing this leakage depends on how the new plant location is modelled. | Studies show that BTAs would be fairly effective at reducing competitive impacts and leakage within the taxed sectors, but that impacts in the rest of the economy would be in the opposite direction. Often the largest source of leakage is the fossil fuel price channel. |

The table does not take account of the differences among sectors: thus free allowances may be most effective at controlling leakage in one sector, one form of BCA in another and another form of BCA in a third sector. Dröge (2009) has conducted some of the initial work in this area, concluding that a "tool needs to be chosen taking into account the characteristics of an industry, including cost structures, international competition, technological status quo and potentially market structures—all determine the leakage potential... Moreover, creation of a policy tool portfolio takes time and requires information." She recommends:

- Direct compensation when climate policy results in high indirect costs (such as increased electricity prices to aluminum producers).
- Border adjustment when climate policy results in high impact on direct or operating costs and the product is homogenous or is not from a process that is capital intensive or incapable of running with plants at partial loads.
- Output-based allocation when the product is not homogenous but all other conditions are the same as above.
- Direct compensation or free allowances with a new entrant reserve when processes are capital intensive and/or incapable of running at partial loads.

Whether different measures for different sectors will be of interest to policy-makers is as yet unclear, but the debate is clearly an interesting one and should be followed.

## 6.0 Would these options be legal under WTO rules?

Both BCAs and free allowances would change competitiveness and hence could alter trade. They would thus be subject to WTO rules as well as those of regional and bilateral trade agreements.

Debate has ranged widely on whether BCAs would breach WTO obligations. This question cannot be answered without knowing the specific design characteristics of the BCA proposed. The attitude of countries toward the BCA would also be important: a cooperative spirit would be much more likely than one of antagonism to lead to a workable BCA.

The debate regarding free allowances is at an earlier stage. Bordoff (2009) and de Sépibus (2009 have suggested that granting free allowances would be in effect a subsidy and should be regulated by rules under state aid provisions and the Agreement on Subsidies and Countervailing Measures.

The UNFCCC staunchly says nothing binding about what measures countries should and should not take, and so has nothing to say on the legality of BCAs or other measures.

### 6.1 Border carbon adjustments

Only a WTO Dispute [Settlement] Panel ruling can give a definitive answer on whether a BCA is legal. A ruling can only be made about a specific BCA, and then only when it has been implemented and when a challenge against it has been raised.[46]

While it is not possible to establish in advance whether a BCA would be legal, legislation and experience do point to which characteristics would make legality more or less likely. The legal treatment would differ depending on whether the measure came in the form of a tax designed to make importers pay in the same way that domestic producers paid in a domestic carbon tax regime (border tax adjustment), or in the form of a requirement to buy allowances at the border in parallel with a domestic requirement for producers to participate in a cap-and-trade scheme where allowances are assigned and/or auctioned.[47]

As noted above, the 1970 report of the GATT Working Party on Border Tax Adjustments was inconclusive on the question of whether a border tax could be applied in the case of a tax on the energy used in the production of a good, and the same uncertainty carries over to tax adjustment on the basis of the emissions embodied in that energy use (GATT, 1970, section XX). A tax adjustment would probably be ruled to contravene GATT's Article III:2, which demands that taxes and internal charges on imports not be applied in excess of those applied to like domestic goods. A key question is whether a cleanly produced domestic good is "like" a good to be imported that has been produced in a GHG-intensive manner, since the latter would be taxed well in excess of the former. WTO jurisprudence suggests that they probably *would* be considered like (GATT, 1987a).[48] The answer to

46 Assessing BCAs in this way is not the WTO's preferred course of action. They would rather refer to an agreed set of external guidelines than be the de facto judges of climate change policy. Nevertheless, such an eventuality remains a real possibility.

47 For further discussion see Ismer (in press).

48 Even if they were not considered like, Article III:2 would probably be violated since the charge would have to be exactly the same or better for the import—a daunting challenge, since it would involve precisely calculating the embedded carbon in the imported product.

this question of "likeness" is also in part the answer to the long-standing question of whether the GATT allows for discrimination on the basis of how a product is produced—in trade parlance, on the basis of processing and production methods (PPMs). If a good produced using a relatively clean PPM is considered to be like a good produced in a polluting manner, then Article III and Article I demand that they be treated equally. This is not the final answer to the question of PPMs, however; as discussed below, PPM-based discrimination can still be saved by resort to GATT's general exceptions.

If the measure in question were a requirement to purchase offsets at the border, as opposed to a tax adjustment, it would, as a regulation, be covered by GATT Article III:4, which requires that imports be accorded regulatory treatment "no less favourable" than that accorded to like domestic products. Likeness under this obligation has been slightly more loosely interpreted than under Article III:2,[49] so it is not clear how a panel would interpret it in a case that discriminated on the basis of the GHG intensity of production. If the products were ruled unlike, the regulatory discrimination would, of course, be allowed.

For both taxes and requirements to purchase allowances, GATT Article I would still need to be respected. This article demands "most-favoured nation" treatment: that any favourable treatment granted to goods from one country must be granted in the same measure to like goods from all other WTO member countries. The key here is that any BCA would need to be equally applied to *all* exporting countries, and not just to those, for example, that were deemed to be lagging behind in the fight against climate change. This is a political process concern, and not related to the question of PPMs and like goods.

For both taxes and purchase–requirements, the obligations under Article I and Article III, if breached, would not be the final word on GATT legality. GATT's Article XX sets out general exceptions—circumstances under which countries may breach GATT's other provisions. The two circumstances that would be relevant here pertain to measures that are "necessary to protect human, animal or plant life or health" and that relate "to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption."

While countries might invoke XX(b) in defence of BCAs, most analysts agree that climate change measures are more likely to be considered under XX(g), since a life-sustaining atmosphere is arguably an exhaustible natural resource (Hufbauer, Charnovitz & Kim, 2009). The language of this criterion has been interpreted to contain two key tests. First, does the measure in question "relate" to the conservation of natural resources? And second, is the measure made effective in conjunction with domestic restrictions? Both a border tax and a request to purchase allowances would likely pass the first test. If treatment of the imports and domestic goods were generally even-handed, the second test would also likely be passed. But note that even-handedness would arguably be violated if domestic producers were given free allocations while importers had to pay for their allowances.

The final question to be considered if BCAs cleared the tests under Article XX(b) or (g) would be Article XX's "chapeau" obligations, which are designed to weed out protectionist measures. The chapeau requires that "measures are not applied in a manner which would constitute a means of

49 The WTO European Community asbestos case gave "like" in this sentence a "relatively broad product scope," and ruled that the health risks inherent in a product could be part of a likeness determination. See http://www.wto.org/english/tratop_E/dispu_e/disp_settlement_cbt_e/a1s1p1_e.htm for the Dispute Panel and Appellate Body reports on the case.

arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade."[50]

The Article XX chapeau has important implications for the application of a BCA, and to some extent its design (though design is more the ambit of Articles I and III). Its interpretation is still in the process of evolution, so how it would apply to any particular measure is hard to predict. Based on what jurisprudence we have, however, we can derive several important guidelines for any BCA whose authors hope it will conform to WTO obligations:

- The measure should allow for "inquiry into the appropriateness of the regulatory program for the conditions prevailing" in the countries of export (Appellate Body, 1998, para. 164). So if the application of the BCA is triggered by a judgement that the exporting country is not serious enough in its climate efforts, that judgement should be formally challengeable. Moreover, the systems of certification and assessing comparable actions should probably involve some degree of input from the affected countries[51] and should probably include an appeal mechanism (Appellate Body, 1998, para. 180–181).
- The measure should allow other countries to meet the conditions of entry in their own way (a finding that applied to a trade ban, but that would probably hold for regulations as well) (Appellate Body, 1998, para. 144). So for example, a BCA that was triggered by the lack of a cap-and-trade scheme identical to that in the importing country would probably be unjustifiable. The trigger should allow for the exporting country to have regulatory regimes that are "comparable in effectiveness."
- The chapeau may demand efforts at international agreement as a prerequisite to the fallback of unilateral measures.[52] If this were so, and if a successor agreement to the Kyoto Protocol were signed, it would make it difficult for a WTO member that is party to the successor agreement to apply BCAs against another WTO member party.[53] International agreement would have been achieved, and the fallback made unnecessary. Any discrimination in the application of the BCA should "relate to the pursuit" of the measure (Appellate Body, 2007, para. 93). For example, exceptions for least developed countries on economic development or equity grounds, since they are arguably not relevant to the environmental aims of the measure, might constitute unjustifiable discrimination.

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50 It is interesting that this language was directly imported into Article 3.5 of the UNFCCC, which commits parties not to employ protectionist trade measures to achieve climate change objectives.

51 This is not a threshold test, but the Appellate Body (1998, para. 172) held that unilateral determinations underscored the unjustifiability of the measure.

52 This is not clear-cut. The Appellate Body (1998) is often credited for this principle, but in fact the finding was that treatment was arbitrary not simply because international negotiations were not pursued with the complainants, but rather because the United States pursued international negotiations with some members but not with others (the others being the complainants) GATT (1987b, paras. 27–28) might also be read as requiring attempts at international agreement.

53 Alternatively, it could be argued that a future international climate agreement may not include a provision on how to deal with leakage and thus that the need for trade measures persists.

Political considerations are important. A trade dispute would be likely to arise if a unilateral BCA were implemented. The result of a WTO dispute settlement panel would require one of two outcomes (Werksman and Houser, 2008):

- Finding the measure does not violate WTO law, thus undermining the UNFCCC's legitimacy as the global regime for climate policy.
- Finding the measure does violate WTO law and exposing the trade regime to criticism from the environmental community for sitting in judgement of climate policies.

The possibility of flexibility remains: WTO members could amend WTO law, reach specialized agreements or grant waivers for the use of certain BCAs (Cosbey, 2008). Such changes would require agreement between most or all WTO members. To achieve this, the members must see the need to reach an agreement as a sufficiently important issue, and the solutions fair and effective enough, to warrant their attention.

The only mandatory PPM-based law to be challenged under the WTO was the U.S. requirement that imported shrimp be caught using nets that excluded sea turtles—a measure that also was cleared as WTO legal, though many aspects of its application violated trade-law obligations.

Voluntary PPM-based discrimination happens all the time—it is a fact of business. Consumers typically buy products and services on the basis of a number of criteria; increasingly, one of these is how the good in question was produced. For example, Home Depot (a U.S.-based home improvement store) now buys only sustainably harvested wood. Perhaps more importantly, many European countries—and other OECD and non-OECD governments—have now developed prescriptive public sector sustainable procurement policies based on various standards and eco-labels (such as the Blue Angel and Forest Stewardship Council). Voluntary discrimination also occurs under eco-labelling schemes that incorporate PPM-based criteria (not all do).

Mandatory standards would almost certainly be referred to the WTO dispute settlement panel, where precedent shows that recourse to the Technical Barriers to Trade provisions would result in the standard being deemed a barrier to trade and thus illegal.

## 6.2 Free allowances

WTO rules are clear that it would not be possible to grant domestic producers free allowances within a country and then require importers to pay for their allowances. Proposals of this type have not currently been put forward under the EU ETS or other schemes.[54]

The provision of free allowances under the EU ETS has been tested to some extent within the European Union's courts. The following conclusions can be drawn (de Sépibus, 2009):

- The question whether the grant of free allowances amounts to state aid under Article 87 of the European Treaty has not been clarified by the European Courts.

54 There is an important principle here for the calculation of an applicable BCA rate. If a domestic producer receives some or all of its allowances for free, an importer's BCA should be reduced by an amount equal to this benefit.

- The legal challenge of allocation rules by affected competitors is fraught with difficulties.
- The European Commission remains the strategic "master" of the state aid "instrument."[55] This allows it to prevent legal action putting the functioning of the EU ETS at risk, and allows it to use the state aid instrument as a "stick" against member states.

Bordoff (2009) considers the eligibility of free allowances within WTO rules. Under the WTO Agreement on Subsidies and Countervailing Measures, free allocation would be a subsidy if it were a "financial contribution" by the government; conferred a "benefit" and were "specific" to certain industries or sectors. Free allowances appear to meet each of these conditions, suggesting that free allowances are a subsidy. To be actionable under the WTO, they need to cause adverse effects to other WTO members. Bordoff concludes that free allowances may not meet these criteria because of the opportunity cost principle, that is, that whether allowances are given for free or auctioned does not alter a firm's decision on how much it will produce. This may be true in the short term, but free allowances would clearly confer a benefit to a firm's profitability and hence its ability to invest in future plants.

Other commentators, invoking the concept of property rights, argue that there is no case to answer and that free allowances do not constitute a subsidy. No case law is established either way.

55 Within the European Union, "The objective of State aid control is, as laid down in the founding Treaties of the European Communities, to ensure that government interventions do not distort competition and intra-community trade. In this respect, State aid is defined as an advantage in any form whatsoever conferred on a selective basis to undertakings by national public authorities" (European Commission, n.d.).

## 7.0 Should competitiveness and leakage concerns be addressed?

Policy-makers and producers are concerned that asymmetric carbon policy could lead to losses in competitiveness and leakage of GHG emission reductions. The available evidence is mostly based on economic simulations, and there are considerable uncertainties as to what the impacts would be. Even if impacts were proven, the question remains as to whether countries should address them. In other words, are the impacts a natural result of reducing GHG emissions in a world where countries have different contributions to historic, current and projected emissions?

Much of the debate around competitiveness and leakage to date has been driven by the competitiveness concerns of energy-intensive industries in countries and regions that either have an ETS (the European Union) or are considering one (such as the United States and Australia). Such industry is only one stakeholder—we also need to consider these industries in other countries, other sectors of the economy in all countries, and who should be responsible for current and future GHG emission reductions.

Either implementing a BCA or compensating domestic industry with free allowances will reduce the competitiveness of exporting countries. BCAs will raise prices for all consumers of the industry's product in the domestic market. Allowances that are given for free represent a loss of potential government income from auctioning.

### 7.1 The UNFCCC: "Common but differentiated responsibility"

While the concerns of affected industry are clearly legitimate, policy-makers should be concerned with the economy as a whole. In the case of GHGs, a global pollutant, policy-makers also need to be concerned with the world economy. The situation is further confused by the debate on who should make the necessary GHG emission reductions. Within the UNFCCC debate, the principle of "common but differentiated responsibility" (CBDR) has been established but not fully defined. Essentially it recognizes that countries should reduce GHG emissions in line with their contribution to historical GHG emissions and their economic capacity to invest in and deal with the constraints of emission reductions.

Outside pure GHG issues, UNFCCC agreements also include an agreement that developed countries should assist developing countries to reduce their GHG emissions by providing them with finance and transferring technology. From the viewpoint of development, increasing competitiveness of developing-country industry relative to that of the developed world is likely to increase employment and GDP within the developing world, which would almost certainly lead to a higher welfare increase than the associated loss of welfare in the developed world.

There is thus a school of thought that holds that CBDR considerations mean that there is no case for seeking to reduce the impacts of climate change measures on competitiveness. This argument could be supported if its proponents could establish that leakage would not be significant; that is, that the majority of emission savings made by industry in countries with carbon costs would not rebound as increased emissions elsewhere. If such leakage is expected to be significant, then the case for reducing leakage by the imposition of BCAs or some other option is easier to support. This is particularly the case if it can be shown that the differences between industries in the developed and developing world is not pronounced; that is, that they use similar technologies and have access to the same levels of capital.[56] Here it is harder to justify an argument that mitigation commitments should be more stringent in developed countries.

The CBDR principle is dependent on the existence of an international agreement. Even if such an agreement were in place, differential carbon costs could remain. A timing question also arises: if a country introduces a domestic policy with a BCA or other measure, should it then remove this measure if there is an international agreement? Or how long should it put its domestic policy on hold while waiting for an international agreement? If no international agreement existed, considerations could clearly be different.

## 7.2 The WTO: Most-favoured nations

If we accept that countries will continue to implement different sets of GHG PAMs over different timescales, and that CBDR is a valid and applicable principle, we must conclude that the costs of complying with GHG PAMs will vary by country.

The WTO's "most favoured nation" principle requires the level of tariffs set on imports from one country to be the same as all others.[57] This appears to be at odds with CBDR. From the point of view of WTO provisions, it could therefore be argued that if no rate can be applied to all countries for a BCA, no BCA should be applied at all.

## 7.3 Political considerations

Developing countries often state their position as viewing BCAs and other potential responses to competitiveness and leakage concerns as some form of protectionism. BCAs are almost certainly more threatening economically than sectoral approaches, yet as described in Table 4.1, the G77 and China's public view of sectoral approaches is that they should not be "a basis to impose trade barriers, punitive trade measures, benchmarking or standards for developing countries." This raises the key concern of whether the potential damage to an international agreement from the imposition of BCAs by some countries is a risk worth taking. A consensus is growing that positive opportunities and cooperation are better than confrontation as a means of going forward in climate negotiations. We must also bear in mind that energy-intensive sectors represent a fraction of world GDP and employment, and that they should expect to contract as industries as the world moves to reduce its GHG emissions.

The perspective of developed countries is generally to address competitiveness first, with leakage concerns secondary. Developing-country focus is often on other sectors, in preference to energy-intensive industry: agriculture, tourism and fisheries are typical examples. This focus supports the view that BCAs and other measures are not likely to bring developing countries to the negotiating table.

A final consideration is that the threat of BCAs may serve a purpose in getting countries around the

56 This is notably the case when an industry is highly globalized.

57 Although "special and differential treatment" does allow for exemptions for least developed countries.

world to agree to other climate change responses. We have not explicitly analyzed this within this paper.

This section has provided only a summary of political considerations. For a full review and discussion, including on the political economy of competitiveness and leakage considerations more generally, see Stephenson and Upton (2009).

## 8.0 Conclusions and recommendations

Is a response to competitiveness concerns a prerogative, or is it protectionism?

This paper has considered many issues in answering this question. This concluding section begins by discussing what we know (and don't know) about competitiveness and leakage, and how the two main response options—BCA implemented as a border tax adjustment and free allowances—compare against a wide range of criteria. The final subsection gives advice to policy-makers: first of a generic nature, and then for the specific case of a policy-maker considering imposing a BCA unilaterally.

### 8.1 What do we know about competitiveness and leakage?

Competitiveness concerns and, to a lesser extent, leakage concerns are real. Given this perception, policy-makers must deal with them, even if analysis shows that the impacts are nuanced and in some cases may not appear worthy of the attention they are receiving.

While it is simple to state that competitiveness and leakage impacts will arise from differential carbon prices and to characterize these impacts, measuring them is a much more difficult undertaking. Empirical experience to date has only come from the EU ETS, over a period of less than five years, with the effects masked by companies' emissions being almost entirely covered by free allowances.

The competitiveness and leakage debate is far from over yet, and if countries engage in more ambitious mitigation commitments, it is likely to grow. Current carbon prices do not reflect the future carbon price levels necessary to achieve the stabilization of GHGs in the atmosphere (IPCC, 2007). For example, the International Energy Agency (IEA, 2008) Energy Technology Perspectives BLUE Map scenario projects that to reach global emission reductions by 2050 of 50 per cent below today's emission levels, marginal carbon prices would need to reach US$200 to US$500 per tonne of carbon dioxide.

Leakage is an often-misused word and a misunderstood concept. Although the replacement of "clean" local production by "dirty" foreign production would contribute to leakage, leakage is a problem principally when production moves from a country or region with an absolute cap on its GHG emissions to one without an absolute cap.

While the common perception is that competitiveness concerns apply widely to the economy, studies indicate that the share of the economy "at risk" is relatively low (typically less that 1 per cent of GDP).

Even in the future, so much will be going on in policy, regulatory and economic space that a long time series of data may still not enable analysts to ascertain the impacts of climate policy alone independently of other factors such as slowdown in demand, changes in exchange rates, and differential labour, energy and tax rates. Both short-term (change in production from existing plant) and long-term (location decisions for new plants and refurbishment or relocation of existing plants) effects are important.

Leakage may require policy intervention when the environmental impact of a policy, paid for within the country that enacted it, has been lessened by a rebound in emissions in other countries. Ideally any such anti-leakage policies would also encourage developing countries to reduce their emissions (such as by giving them an implicit carbon price).

A major challenge is to devise measures to combat carbon leakage without compensating more than is necessary. There is a risk of using climate policy as a proxy for industrial policy, which could undermine a climate policy's effectiveness by overcompensating carbon-intensive industries. Therefore the challenge for governments will be to provide tailored solutions to deal effectively with the different leakage channels, such as leakage from production, investment and fossil fuel pricing, which may not require the same type of action.

These issues lend weight to the argument for ultimately creating a global cap-and-trade regime that is as inclusive as possible. The more countries participate under the same constraints, the less the scope for carbon leakage and competitiveness concerns, particularly if all major economies participate.

## 8.2 Comparing the available options

Neither free allowances nor BCAs deal fully with competitiveness and leakage issues, let alone the range of secondary issues that implementation of the options could lead to. Even as we compare the two options, we must realize that they would not be fully effective in meeting their policy goals.

Policy-makers do their work within a context of uncertainty and must make trade-offs among policy goals. Thus, granting free allowances may avoid a trade dispute, but may be ineffective at dealing with either competitiveness or leakage. And we may not have the data we need to evaluate the performance of the chosen option, either because there is little empirical data as yet or because it is not possible to separate out the effects of a single policy from those of all other PAMs affecting the decisions GHG producers make.

This paper has concentrated on the two main options under consideration by policy-makers: BCAs implemented as border tax adjustments, and free allowances. It appears that BCAs may be more effective than free allowances, but that the fossil fuel leakage channel may largely erode much of this extra effectiveness. BCAs give rise to more political controversy: much has been said about the damage they may do to international climate negotiations, but they also give countries pursuing unilateral carbon policy more confidence to implement their measures. BCAs are likely to be more complex to implement than free allowances, with measurement of carbon content and legality under the WTO the dominant considerations.

Policy-makers must carefully compare, in advance, the pros and cons of implementing any option. Objectivity is critical: using these options for other purposes (such as industrial policy or protecting domestic jobs) is likely both to be inefficient in meeting these other aims and to lead to significant collateral damage to the climate negotiations.

Proposals need to be considerably more detailed before we can assess them further. A relatively simple example of the detail needed is a definition of what body would set default values for carbon contents of goods, and the rights of appeal to this body; we could quote similar examples across the list of design parameters.

## 8.3 What should policy-makers do?

Policy-makers should keep the following general principles in mind:

1. Understand that *tackling climate change will involve fundamental economic and technological restructuring*. This includes changing patterns of global energy production, transportation, manufacturing and consumption. Any exemption or differential treatment of carbon activities implies a higher cost to the economy. Clearly there are political costs, but the risk of leakage cannot be an excuse for inaction.
2. *Decide whether a case for intervention exists*. Key considerations are whether there is, or is expected to be, an international agreement allowing for different national carbon commitments, and whether a significant loss of environmental integrity through carbon leakage is likely.
3. *Define what the policy is trying to achieve*. Some of the competitiveness and leakage debates actually centre more on industrial policy, with climate change playing only a partial role.
4. *Bear in mind the goals of policy more widely*. Will responses to competitiveness concerns help or hinder the need to reduce GHG emissions, since countries cannot support carbon-intensive industries for the very long term? And how will they affect development, particularly in those countries that most need it?
5. *If they decide there is a case for intervention, decide which sectors of the economy are at risk of competitiveness loss*. They must then decide between the economically more efficient but politically more damaging BCAs and some form of industrial support (generally free allowances).
6. *Be aware that developing the details of the scheme selected will involve difficult choices and will have a major impact on the distribution of wealth*. Within both BCAs and alternatives, there are devils in the details. Defining and setting up a scheme for assessing the life-cycle emissions embedded in imported goods is a major undertaking. Decisions on the number of free allowances companies should receive and the conditions regarding updating, plant closures and new entrants can lead to radically different incentives.
7. *Continue research and create transparent and flexible policy*. It is not yet clear whether responses to competitiveness concerns are a prerogative or a form of protectionism. This requires continuing research to improve understanding, policy-making that is sufficiently transparent and has a long enough time scale to allow all voices to heard, and policy that is flexible enough to be altered as information and understanding improve.

We can also offer some specific advice for policy-makers considering unilateral BCAs. This section started with the assertion that competitiveness concerns and, to a lesser extent, leakage concerns are real. So what should a policy-maker do when confronted with the competing needs of reducing overall emissions and concerns about losing competitiveness?

One of the major manifestations of this dilemma is the current debate around implementing a BCA unilaterally, notably in the United States. The work within this paper and within the literature more generally demonstrates that there is a big difference in the impacts, economic and political, between a well-designed and a badly designed scheme. It also demonstrates that waiting for all the uncertainties in the effectiveness of options to be understood is not a practical strategy—some of the uncertainties may be permanent, and in any case, politics are dictating the need for policy in the near term.

IISD, in conjunction with a set of partner organizations,[58] has responded to this challenge by beginning to develop guidance on elaborating and applying BCA measures. Appendix A shows a version current as of November 13, 2009. The guidance does assess whether a BCA should be applied: rather, it aims to advise states that have decided to implement a BCA on how best to do so. It covers the following issues:

1. *Starting point*. BCAs should only be used as a fallback measure, such as when the international community has not reached a multilateral agreement, and only as a response to leakage.
2. *National-level institutions in the importing country*. These should be covered by clear rules and mechanisms.
3. *Vulnerable sectors*. Policy-makers should define these based on robust data, using existing protocols if possible.
4. *Country-level applicability (the "trigger")*. Countries will have different national responsibilities.
5. *Level of adjustment*. Policy-makers should determine this by taking into account all climate policies and free allowances.
6. *Review and assessment*. Measures should be time-limited and regularly reviewed.

We plan to develop the guidance progressively, starting with the views of non-governmental organizations and international governmental organizations, and working through to states. The principles we develop could ultimately be used to guide decisions by the WTO or the UNFCCC. Guidance could similarly be developed for the implementation of free allowances.

58 Including individuals from the World Resources Institute, the OECD Round Table on Sustainable Development and the World Bank (whose contributions should not be held as being representative of their organizations).

# Appendix A Guidance on elaborating and applying border carbon adjustment measures[59]

We provide this list without making any judgments as to the need for BCAs. We note at the outset that BCA is at best a fallback measure in the event of collective failure at the international level to define appropriate levels of action at the national level. At worst, BCA can be a coercive, divisive and highly imperfect policy tool with serious methodological challenges. As with all policies, we recommend that BCAs as a policy option be judged against a full set of alternatives for meeting the prescribed goals and measured against a full list of criteria (such as economic effectiveness, environmental performance, political impacts and social impacts). At the end of this paper we feature some of the rich body of work devoted to such analysis.

We assume that BCA may eventually feature in the domestic regimes of some states taking action on climate change. Accordingly, we offer here guidance for national-level policy-makers charged with elaborating and/or implementing those schemes, and for exporting nations that seek to assess schemes under which they might be targeted. Our aim is that BCA be formulated and carried out in a manner that is minimally disruptive to trading partners, equitable in terms of impacts, effective in achieving the goal of addressing competitiveness impacts and leakage,[60] and in line with the principles of the multilateral system of trade and the multilateral climate change regime. While this guidance takes much from international law, we do not intend to advise on the question of whether a given BCA regime will comply with legal obligations under the WTO or the UNFCCC.

Our aim is to circulate and consult widely enough to refine this list to a level where it will have broad acceptance as a valid guide to practice. Initially we seek the input and buy-in of a smaller group of non-governmental organizations and international governmental organizations, but the aim is to consult more broadly as well, eventually involving states. The more widely accepted this guidance is, the more force it will have as a reference point—a measure by which domestic schemes will be judged by domestic observers and target countries and firms. With a wide enough level of acceptance such guidance might even be recognized as relevant in dispute settlement under the WTO, although we cannot hope for it to have the same sort of legal force as an international treaty. Ideally, a set of principles based on this agreement would be adopted in the WTO or UNFCCC, though in the foreseeable future this seems unlikely.

**Starting points:**

- BCA should only be used as a fallback measure—a recourse when the international community has failed to reach a multilateral agreement on climate change action. Such international agreement is the first, best option for addressing competitiveness and leakage concerns.

59 Version current as of November 13, 2009.

60 The only legitimate *environmental* objective for measures that address these issues is the avoidance of leakage. However, such measures are clearly also aimed at blunting negative competitiveness impacts, and will undoubtedly feature as part of a suite of measures intended to lower the costs of transition to a low-carbon economy.

- BCA should only be used as a method for addressing leakage concerns—concerns over the environmental effectiveness of climate change regulations. It should not be used as a coercive tool to force other states to take action to address climate change, or as a tool to preserve the competitive position or market share of domestic firms in the importing market or third-country markets.

**National-level institutions in the importing country:**

- Countries should have clear, predictable and understandable rules, fully disclosed and with trading partners notified in advance. Countries should establish an enquiry point that exporting countries and firms can turn to with questions and requests for relevant documents.
- The country should provide mechanisms for broad international input on regime design (prior consultation), similar to those available under the TBT Agreement.
- There should be mechanisms whereby foreign firms can appeal decisions that concern them.
- The decision-making process should be predictable and transparent.
- Calculations with respect to the parameters of the scheme should be regularly reviewed—on at least an annual basis.

**Determining vulnerable sectors:**

- Reporting of data necessary for the scheme (for example, GHG emissions or quantity of production) should follow existing conventions, such as the GHG Protocol or the evolving ISO guidelines.
- While the ideal determination of sectoral vulnerability would be a complex process of determining such things as elasticity and cost pass-throughs, in the final analysis, any workable regime would need to use a system that is simple enough to be operational based on reasonably available data.[61]

**Determining country-level applicability (the "trigger"):**

- If the exporting country is part of a multilateral agreement to address climate change and is in compliance with its obligations under that regime, it should not be subject to the BCA.
- The exporting country should also have the chance to be exempted from BCA by a determination of comparable effort. Such a determination should consider overall effort in the exporting country, and not just the regulatory regime, cost structures or emissions levels as they apply to any particular sector. For example, an importing country should not apply a BCA that would punish an exporter's cement sector for a lack of action if adequate national-level action has occurred as a result of efforts in other sectors.

61 All the research to date tells us that the number of vulnerable sectors will be limited. Any parallel attempts to craft sectoral approaches to dealing with leakage concerns should be mined for the valuable information and data they could provide.

- The importing country needs to account for the differences in regulatory regimes from country to country in dealing with climate change. That is, countries should demand a final result, and not specific mechanisms that might achieve that result, though importing countries may be tempted to demand mechanisms identical to those in the importing country.
- The importing country should abide by the principle of common but differentiated responsibility. In other words, BCAs should not be applied to least developed countries or those with low historical responsibility or low GHG emissions—or their application should be reduced. This implies that the full cost difference of meeting carbon mitigation policies will not always be levied.[62]
- Discretion on whether to pull the trigger should exist at a level where decision-makers have cognizance of broader public policy goals. That is, while the conditions that trigger a BCA should be transparent and predictable, the actual decision to employ BCAs once those conditions have been met should not be automatic.[63]

**Determining the level of adjustment:**

- The basis for accounting should be production, not consumption. That is, the exporter should only be held responsible for emissions from production and processing, but not for emissions from consumption and disposal of the goods.[64]
- The importing country should base the level of adjustment on effective costs of compliance with all carbon mitigation policies.[65] That is, when assessing costs to the sector in question, the costs of all policies must be considered, including policies that may be primarily targeted at industrial efficiency or energy security.
- If cost of compliance is used, it should, to the extent possible, be determined from physical output and input data—determinations that involve the use of financial information will be difficult to administer and may be non-compliant with commercial confidentiality rules.
- Any free allowances or other compensatory mechanisms to shelter domestic firms need to be taken into account when calculating the amount of adjustment

62 One way this could be achieved, other than determining non-applicability, is by a assuming a favourable performance for the producers. For example, the importing country could assume that all imports from least developed countries have used best available technology.

63 The U.S. Waxman-Markey bill would give the president the discretion to determine that application of a BCA in any particular case is not in the national interest. However, that determination would have to be confirmed by a joint resolution of Congress.

64 Revisions of the guidance will also deal with transport emissions.

65 We argue here that even non-climate-related policies (such as energy security) should count when the home country determines the cost of compliance (and comparability of effort). For one thing, such policies have major climate benefits. For another, it is impossible in practice to demonstrate the intent of a policy—countries would simply rename their policies to make them appear to be climate motivated. But this is still an open question. On the other side of this argument, it is extremely difficult to compare costs across different sorts of policy tools. It would be much simpler to only consider carbon taxes or ETSs as schemes that count in cost comparisons or that count in determining comparability of effort.

due. Depending on the regime, this might conceivably mean that the level of BCA is adjusted down to zero.[66]

- Exporting country emissions would ideally be calculated at the level of the plant. This may be difficult in practice, so sectoral world averages or country averages might be used. In such cases, however, individual firms should always have the ability to challenge the assessed emission levels for their particular circumstances.
- Calculation and reporting of data necessary for the scheme (for example, GHG emissions) should follow existing conventions, such as the GHG Protocol or the evolving ISO guidelines. The engagement and cooperation of industry associations is likely to be valuable.

**Review and assessment:**

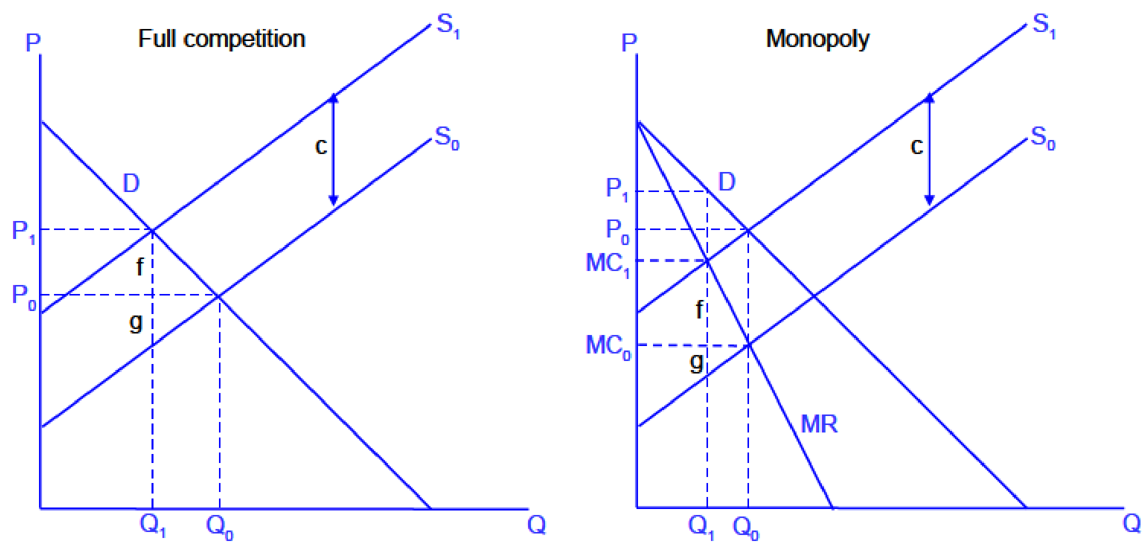
- The regime should include a procedure for regular review of measures and assessment of their effectiveness in meeting their stated objectives.
- The measures should be time limited, as their intent should only be to offer temporary effect during a period of transition to a low-carbon economy.

66 Compensatory mechanisms could even constitute a subsidy that would, in theory, mean that the adjustment should be negative. It would, of course, be rather idealistic to recommend that BCA regimes should recognize this possibility, but it is worth noting nonetheless.

## Appendix B The economics of market structure

Figure B.1 shows the economic impact of adding a carbon opportunity cost (c) to the cost of supply ($S_0$) under perfect competition and monopoly market structures. In both cases, the pass-through cost (f, calculated as $P_1$ minus $P_0$) is lower than c, showing that the firm is not able to pass through 100 per cent of the opportunity cost. The figure also illustrates the importance of market structure. Market equilibrium prices before and after the imposition of the carbon price exhibit major differences if there is full competition or a monopoly. Energy-intensive markets tend to be dominated by a relatively small number of players, with market structure probably closer to monopoly than to full competition.

**Figure B.1 Pass-through of carbon costs under full competition versus monopoly, facing variable marginal costs and linear demand. Reprinted from Sijm, Hers, Lise & Wetzelaer (2008).**




In the figure, the cost pass-through is the ratio f/c. This ratio is not a direct measure of either competitiveness or leakage. What we can work out from the change in market equilibrium is what the loss in producer surplus is—essentially this is a measure of lost profit, and if governments wish to compensate firms for lost earnings, compensating for lost producer surplus is one option. In the figures above, the producer surplus is the triangular area bounded by the demand curve, the y-axis and the horizontal line at the equilibrium price. It is clear from the figures that the producer surplus is significantly lower at the equilibrium price $P_1$ (when it includes the carbon opportunity cost) than when the price is $P_0$ (when the carbon opportunity cost is not included). It is important to take account of the cap type and allocation when considering potential compensation. If there is an absolute cap and the pass-through cost is relatively high, then the government should not allocate many allowances to the firm for free, or it will risk overcompensation. Such "windfall profits" received much attention during the first phase of the EU ETS (2005 to 2007), when it was largely established that some sectors (notably electricity generation) were able to pass through a very high proportion of the opportunity cost to consumers yet were still receiving essentially all of the allowances needed to cover their emissions for free.

Finally, it is important to note that there are many different representations of supply and demand curves and that that these have a significant impact on cost pass-through rates, producer surpluses, competitiveness and leakage. Table B.1 shows a set of formulations of the pass-through rate for a matrix of supply and demand functions, as a function of the number of firms (N) competing in the market. While we can state that suppliers cannot pass through costs if demand is perfectly elastic, and can pass through 100 per cent of costs if it is perfectly inelastic, it is much more likely that demand will lie between these two extremes. Here, calculating the pass-through cost will require assumptions on the shapes of the supply and demand curves and on the level of competition in the market. These are both sector specific and very difficult to define in practice. This leads to a key conclusion: attempting to model expected levels of competition and leakage to any level of precision is essentially impossible. Policy-makers thus tend to use much simpler indicators of whether a sector is "at risk" of competitiveness impacts and leakage, and devise simple algorithms for how firms should be compensated for an assumed loss.

**Table B.1** **Overview of cost pass-through formulas for different market structures, assuming profit maximization among producers. Reprinted from Sijm et al. (2008).**

| | | Demand function | | | |
|---|---|---|---|---|---|
| | | Perfect elastic | Perfect inelastic | Linear | Constant elasticity |
| | $PTR_1 = \frac{dp}{dMC}$ | 0 | 1.0 | $\frac{N}{N+1}$ | $\frac{N\varepsilon}{N\varepsilon - 1}$ |
| | $PTR_2 = \frac{dp}{dCC}$ | | | | |
| Supply function | Perfect elastic | N.A. | 1.0 | $\frac{N}{N+1}$ | $\frac{N\varepsilon}{N\varepsilon - 1}$ |
| | Linear | 0 | 1.0 | $\frac{c}{d + c + c/N}$ | $\frac{1}{\left(1 - \frac{1}{N\varepsilon}\right) + bP^{-\varepsilon-1}}$ |
| | Constant elasticity | 0 | 1.0 | $\frac{1}{1 + \frac{1}{N} + \varepsilon b\left(\frac{Q}{Q_0}\right)^{b-1}}$ | $\frac{1}{\left(1 - \frac{1}{N\varepsilon}\right)(1 + b\varepsilon)}$ |

PTR is pass-through rate, dp is the change in price, dMC is the change in marginal costs, dCC is the change in carbon costs, N is the number of firms active in the market, 1/b is the price elasticity of supply (b>0), -ε is the price elasticity of demand (ε>0), c is the slope of the inverse, linear demand function, and d is the slope of the inverse, linear supply function.

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## 10.5 Industry associations

Cement Sustainability Initiative: http://www.wbcsdcement.org

International Aluminum Institute: http://www.world-aluminium.org

World Steel Association: http://www.worldsteel.org

## 10.6 Other

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