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Carbon Leakage

Theory, Evidence and Policy Design

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Carbon Leakage Theory, Evidence and Policy Design

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Executive Summary

What Is Carbon Leakage?

There is growing, global momentum for tackling carbon emissions and correcting “*the largest market failure history has seen*” (Lord Stern). Often this action involves the use of carbon prices—established either through carbon taxes or through cap and trade schemes—in recognition of their ability to achieve emissions reductions in a flexible and cost-efficient way. The introduction of carbon pricing forces firms and consumers to take account of the full economic costs associated with their production and consumption decisions. It therefore promotes a level playing field between polluting activities that impose climate change adaptation costs (and/or climate damages) on others and low-emissions activities that do not. In this sense, the *absence* of a carbon price can be thought of as a *subsidy* for “dirty” production. Reduction of these implicit subsidies and assigning cost of emissions to those who can control them is an intended goal of carbon prices. It leads to structural transformations and eventually more efficient allocation of resources in the economy. Stringent climate policies have also been found to stimulate clean technology innovations, in particular, among more advanced firms. Such technologies tend to have strong innovation multiplier (spillover) benefit throughout the economy, comparable to nano-technologies and robotics, unlike innovation in traditional fossil fuel-based technologies.

But this transformational economic impact of carbon prices may be skewed if the stringency of carbon price policy significantly differs between jurisdictions. Today climate action is still led by individual national and subnational jurisdictions. Despite the well-recognized benefits that could arise from a globally harmonized approach to regulating emissions (especially through carbon pricing), most countries are yet to decide whether and when to follow. Establishing carbon-pricing policies requires both supporting technical and institutional regimes, such as emissions measurement and verification, which may be challenging in countries with weaker capacity. It also involves substantial political debate and decisions. The trend seems to be changing, however, and the momentum for putting a price on carbon emissions is growing. According to the recent World Bank State and Trends in Carbon Pricing Report (World Bank Group 2014b)—around 40 countries and over 20 subnational jurisdictions are taking action to implement carbon pricing—from almost none 11 years ago. The number of carbon pricing initiatives doubled and the emissions covered trebled only since January 2012.

Before a critical mass of countries with a converging emissions price emerges, different stringency of policy ambition creates the risk of carbon leakage. Carbon leakage occurs when an emissions-reduction policy such as a carbon price inadvertently causes an increase in emissions in other jurisdictions that do not have equivalent emissions-reduction policies. This increase in emissions in other jurisdictions may arise because the differences in the costs of complying with policy can cause a shift in the location of production. If the emissions intensity of production in jurisdictions that see an increase in production is greater than in jurisdictions where production falls, it is conceivable that, under extreme circumstances,

this could even lead to a net increase in global emissions. As more and more jurisdictions move to adopt climate policies, including carbon pricing, the risk of emissions leakage and the distortions it may create will diminish and eventually disappear.

If it occurs, carbon leakage has the potential to have undesirable environmental, economic, and political consequences. Carbon leakage could undermine a carbon-pricing policy's environmental objective by causing emissions to increase in jurisdictions beyond the reach of the policy. This also implies that the economic cost of meeting a global climate stabilization objective would increase. Fear of leakage prevents international cooperation to mitigate climate change, as political leaders are often concerned that other countries will free ride on their effort. At home, the associated decline in domestic production and, hence, possibly, employment can create significant political challenges. This confluence of potentially undesirable environmental, economic, and political outcomes means that the risk of leakage is always one of the most controversial and important aspects when considering the design of carbon-pricing mechanisms (and, indeed, other carbon regulations).

Assessing Carbon Leakage

Modeling approaches are a valuable way of assessing the risk of carbon leakage. They provide understanding and evidence of carbon leakage risk that informs the judgment of experts or politicians and aid the transparency of any subsequent decisions.

There are two main approaches to modeling carbon leakage and carbon leakage rates that are described in this note.

- An empirical or “ex post” approach which tries to identify changes in patterns of emissions and production in historical data;
- A theoretical or “ex ante” approach which attempts to assess the impact of policy by comparing different modeling scenarios with and without the simulated impact of the policy.

Ex post modeling analyses have generally found little evidence of leakage. Almost all of these studies have been based on experiences in the EU ETS and European carbon taxes. The results are consistent, however, with the analyses of the impact of other local environmental policies that have been observed for a longer time in a wider range of countries. Ever since the 1970s they were also feared for causing the potential migration of industry to “pollution heavens” abroad, which has not materialized on a significant scale. Environmental policies have even been found to induce innovation that offsets part of the cost of compliance with the environmental policy. This is not surprising for economists who have long observed that firms do not compete on costs only, but on the overall efficiency of converting various inputs (including knowledge) into high-value products and services. Cost competition is more important to sectors offering homogenous products and commodities. Having said that, it is difficult to know for certain what explains the ex post modeling result of carbon leakage in Europe so far. While it could mean that the risk of leakage is negligible for the reasons described above, it could also be explained by the technical difficulties in identifying impacts over a relatively short period of time; or because carbon prices have been modest; or because of the efficacy of leakage-prevention mechanisms that have been part of policy design from the outset.

Ex ante modeling analyses suggest a wide range of potential leakage rates indicating large uncertainty.

It implies that going forward the risk of carbon leakage cannot be dismissed. Two ex ante modeling approaches have been used with varying results on the risk of leakage:

- Computable General Equilibrium (CGE) modeling analyses tend to find a more narrow range of relatively small whole-economy leakage rates¹ (in the region of 5–15 percent). This approach uses large-scale CGE models that capture and highlight the effect of climate policy on production and emissions outcomes taking into account interactions and feedbacks across all sectors and markets.
- The range of leakage estimates from partial equilibrium models is much wider, suggesting possible future leakage rates between 0 and 100 percent, depending on assumptions and model specification. This approach uses partial equilibrium analysis to model detailed output and emissions patterns at the level of an individual sector in which only a subset of firms faces a carbon price (or another form of carbon policy), but ignores the interaction of that sector with the wider economy.

Both of these approaches have advantages and disadvantages; ideally they should be used in concert. CGE models tend to forecast lower leakage rates because they provide results for a blend of sectors that are more and less heavily exposed to leakage, while partial equilibrium models tend to focus on individual sectors expected to be particularly vulnerable to carbon leakage.

Managing the Risk of Carbon Leakage

Concerns about risk of carbon leakage have led most jurisdictions that implement carbon prices to design leakage-prevention mechanisms. The art of leakage policy design is to try to correct for the challenges that emerge when carbon prices are not yet globally harmonized, while, at the same time, not undermining the benefits that are expected from the carbon pricing in the first place, and not creating more distortions than such measures aim to rectify.

In addressing this challenge, there are two key (and interrelated) questions that policy makers need to consider:

- Which sectors should be targeted (supported) by the leakage prevention mechanism?
- What form should that leakage prevention mechanism take?

In terms of sectoral coverage, there is often a trade-off between policy integrity and political acceptability.

On the one hand, leakage prevention mechanisms often involve the use of, or foregone, revenue that could be used for other purposes; and can undermine abatement incentives, which tends to point to

¹ A carbon leakage rate is defined in terms of the increase in emissions in the jurisdiction without a carbon price (or with a lower carbon price/less stringent regulation) expressed as a percentage of the decrease in emissions in the jurisdiction with a (higher) carbon price (or more stringent regulation). For instance, if the introduction (or further strengthening) of carbon pricing resulted in total carbon emissions in one country declining by 200 tones and foreign emissions increasing by 60 tones, the leakage rate would be calculated as 60 divided by 200, and expressed as 30 percent.

limiting the scope of the prevention mechanism. On the other hand, given the risk of carbon leakage could be real for some activities and the need to ensure sufficient political support for carbon pricing, coverage of leakage prevention measures may be more expansive. Different schemes have traded off these pressures in different ways and according to the maturity of the scheme. As individual schemes evolve, there has been a general trend toward narrowing the breadth of sectors that are targeted by the leakage prevention mechanism.

The most reasonable approach is to target those sectors that are truly vulnerable to carbon leakage.

Typically this combines an assessment of the carbon intensity of firms with an assessment of their trade exposure. Carbon intensity captures the *impact* that carbon pricing has on a particular firm or sector. As carbon leakage is driven by carbon emission cost differentials between jurisdictions with and without carbon prices, the larger the impact of a given carbon price on sectors or firms, the greater the risk of leakage, all other things being equal. Trade exposure can be thought of as a proxy for the ability of a firm or sector to pass on costs without significant loss of market share and hence their *exposure* to carbon prices. Where factors such as trade barriers or transport costs make trade unlikely to occur, covered firms are insulated from competition from uncovered competitors and the risk of carbon leakage should be small. These assessments are likely to be better undertaken at the sectoral level than at an individual firm level: in the latter case, there is a risk of creating perverse incentives for firm behavior in order to ensure eligibility, and administrative costs are also likely to be higher.

Periodic reassessments of the risk of leakage and adjustments in the coverage and the type of risk-mitigation measures may be required in the future. In particular, to date most countries that have factored in trade exposure to their assessment of which sectors may be at risk of leakage have done so with an implicit assumption that no other country or region in the world has an equivalent policy. With a growing number of countries taking action to address emissions, this approach may become increasingly difficult to justify. There may also be a need to acknowledge the diversity of instruments that countries can use to reduce emissions, as some jurisdictions may use policy instruments other than carbon pricing that may have even higher embedded costs and therefore still be relevant for assessing the risk of leakage.

If some sectors have been assessed as being truly vulnerable to carbon leakage, a choice must be made on the most appropriate form for any leakage prevention mechanism. The main options available are:

- under an emissions trading scheme, the provision of free allowances allocated on a grandfathering approach, where allocations are proportional to an individual firm's historical emissions and there is no rapid adjustment if firms change their output;
- under an emissions trading scheme, output-based allocations (OBAs) of free allowances, where allocations are based on product-specific benchmarks and changes in output lead to rapid changes in allowance allocations;
- under an emissions trading scheme, fixed sector benchmarks (FSB), where allocations of free allowances are based on product-specific benchmarks (as with output-based allocation) but without rapid adjustment if there are future changes in output (as with grandfathering);
- rebates, either directly or through other taxes;

- administrative exemptions; and
- border carbon adjustments (BCAs).

BCAs theoretically perform most strongly on grounds of leakage prevention and abatement incentives, but face political, administrative (and, possibly, legal) challenges. They are appealing in that they simultaneously offer the potential to remove the competitive distortion associated with asymmetric carbon pricing, while ensuring that the firms with the lowest carbon intensities are at a competitive advantage, and also ensuring that demand-side abatement incentives are maintained. However, their application to carbon regulation remains largely untested, with proposals to date facing strong opposition and technical challenges.

At the other end of the spectrum, exemptions perform most weakly in terms of abatement incentives but will be the easiest to implement. They are likely to be appropriate only as an interim measure to ensure sufficient support for carbon pricing when a scheme is in its infancy.

Of the free allocation approaches, those that utilize benchmarking (either OBA or FSB) are generally preferable to providing free allowances on a grandfathered basis. The attraction of both benchmarking approaches is that they sever the link, which exists under grandfathering, between a firm's own historical emission levels and its free allowance allocation. Unless this link is broken, there is a risk that firms will have little incentive to reduce their emissions intensity, as lower emissions in one period will be expected to lead to fewer free allowances in the future. While the creation of benchmarks may incur some additional administrative costs, the experiences of the EU, Australia, New Zealand, and California—as well as the intention of South Africa (in a carbon tax context)—suggest that these challenges can be overcome. Benchmarking can also create a “race to the top” among firms—by rewarding production efficiency and emission intensity performance that is better than the benchmark. Grandfathering may be more appropriate when a scheme is in its earlier stages, where the need to tackle other administrative challenges may make benchmarking approaches appear too complex, or where there is a desire to provide assistance for firms even if they are not at risk of leakage.

Between the two benchmarking approaches (FSB and OBA), the trade-offs are more balanced. OBA may be more effective at preventing leakage but, depending on the specific design, can make the environmental outcome more uncertain because the number of allowances issued changes with the current production level, akin to a tax. Policy can be design to ensure a fixed cap with OBA by, for example, adjusting the number of allowances auctioned to offset increases or decreases in free allowances. If it does not ensure a fixed cap and production increases then this could result in a lower carbon price, and hence final product prices than an FSB approach, possibly blunting demand-side abatement incentives. This will be particularly problematic if OBA is applied to sectors where the risk of leakage is limited (and hence where prices would otherwise rise). Furthermore, OBA may have higher administrative costs than an FSB approach, because production levels must be reported and verified.

Under a carbon tax regime, rebate mechanisms can be designed to emulate the properties seen under the free allowance benchmarking options. An output-based rebate, such as that used in the case of the Swedish NO_x charge, provides very similar properties to OBA; alternatively, lump-sum rebates would

resemble FSB approaches. Rebates through reductions in corporate income taxes or employer social security contributions represent an alternative that may reduce the risk of leakage without reducing incentives to reduce emissions. Given these similarities to the free allowance alternatives, the trade-offs between the different approaches, and the circumstances in which any one approach might be preferred, are also similar.

Complementary measures can also be used to guard against leakage risk. These measures include cash transfers to offset some of the carbon emission costs firms face, direct support for emissions-reduction projects, and energy efficiency measures. While these measures may be valuable in helping to deliver emission reductions, they typically have only an indirect impact on leakage and are unlikely to obviate the need for more integrated approaches.

Importance of Engaging with Stakeholders

Carbon leakage has already gained significant prominence in the overall policy debate around the introduction of carbon pricing. It is probably the single most common argument used to delay or derail the introduction of carbon prices around the world. Although the risk of carbon leakage is likely to be real at least for some activities, with genuine environmental implications, the arguments can be inflated by some stakeholders to capture windfall profits, seek trade protection from fair competition or just to fuel political opposition to the carbon price policy, especially during election campaigns. On the other hand, it can be too easily dismissed when the risk is real. The challenge of finding the right balance is aggravated by asymmetries of information between different stakeholders—policy makers, industry, and civil society. How this policy debate is managed can have a great influence on the successful design of leakage prevention policy and the successful introduction of a carbon price.

Stakeholder engagement allows for relevant parties throughout a society to be appropriately consulted and informed on issues relating to carbon leakage and the design and implementation of prevention measures. Stakeholder engagement comes in many different forms, capturing a wide range of relevant stakeholders, and using any number of different modes of engagement.

Stakeholder engagement on carbon leakage can be difficult and involve some conflict but has significant benefits, such as greater transparency in the policy debate; avoiding misinformation, resolving conflicts, and securing consensus and buy-in; ensuring policy reflects national priorities and circumstances, and draws on widespread expertise; enhancing trust between stakeholders and alleviating general skepticism; and helping raise and maintain public support.

There is no single approach to stakeholder engagement which is suitable for every situation. Stakeholder engagement will depend on the context in which it happens. With such a wide variety of cultures, communities, business practices, government processes, and transparency mechanisms in place across the world, different jurisdictions have taken different approaches to stakeholder engagement. Some of the modes of engagement that have proved successful to date include:

- formal consultation to seek written views and input on policy proposals
- surveys and questionnaires to gain information and views from stakeholders

- consultation meetings with stakeholders that may be one to many, one to some, or one to one meetings.
- establishing representative committees
- media campaign including radio, television, newspapers, and social media to explain policy and address concerns
- other modes such as web pages, frequently asked questions, webinars, phone calls, and letters.

An important aspect of engagement is how the introduction of a carbon price and any associated concerns about carbon leakage are framed. Different governments have taken different approaches for framing the debate, including by:

- framing concerns about carbon leakage within a comprehensive carbon price policy narrative;
- using a strong evidence base to frame the debate and address misinformation;
- testing specific claims about risk of carbon leakage with a range of stakeholders to more fully understand the real risks;
- having a clear and easy-to-understand narrative about the objective of leakage prevention measures;
- making explicit the trade-off between leakage prevention measures and other uses of the fiscal resources to help balance interests; and
- packaging the introduction of a carbon price and associated leakage concerns into a broader policy reform package.

Experience has shown that with the introduction of a carbon price incentives for lobbying can be high, with strong vested interests who may use arguments around carbon leakage to protect those interests. **A clear and sensible public policy framework supported by strong evidence and information can therefore help to manage the debate.**

Some political judgment will be required to formulate the most appropriate policy response. Compromises and trade-offs may be needed to find a policy formulation that is politically acceptable. High-level political leadership and commitment may be needed to drive the agenda.

Public opinion and therefore political support can shift overtime. There can be a trade-off between engaging in a long policy development process to design the perfect policy and getting the policy implemented while there is political support and/or momentum. In any event, carbon pricing policy, in particular, measures to address the risk of carbon leakage, can be reviewed and improved over time.

1. Introduction

A Technical Note to Support Knowledge Sharing on Carbon Leakage

1.1. Background and Terms of Reference

The World Bank's Partnership for Market Readiness (PMR) brings together developed and developing countries to build readiness for carbon market instruments to support cost-effective greenhouse gas emissions reductions.

As part of the PMR's Technical Work Program, the World Bank asked Vivid Economics to develop a technical note on the issue of carbon leakage and competitiveness. This issue is of interest to a range of PMR countries and is of great importance to successful design and implementation of carbon pricing policies.

The terms of reference identify three broad questions.

- How to evaluate the expected competitiveness and carbon leakage impacts (negative and positive) due to carbon pricing policies for different sectors and the entire economy?
- How to mitigate the risk of negative impacts and strengthen the positive impacts (through instrument design or complementary policies) in the short and long term, and for different levels of expected decarbonization?
- How to manage the process of dialogue between a government, business, and civil society on the implications for competitiveness and risks of emissions leakage, and their mitigation?

The first two of these questions have been analyzed by Vivid Economics, with oversight and input from the World Bank. The third question has been analyzed by the World Bank with the assistance of a survey conducted by Vivid Economics.

The analysis is based on desktop research and consultation with relevant experts, including both policymakers in jurisdictions with carbon pricing policy experience and independent experts.

1.2. The Issue of Carbon Leakage

Carbon leakage is much discussed in carbon pricing policy. Stakeholders, especially emissions-intensive industries, have expressed concern about the implications of carbon pricing when they compete with firms located in jurisdictions without equivalent policies. Two related concerns are often expressed. First, by imposing costs on firms that their international competitors do not face, their competitiveness will be harmed. Second, this loss of competitiveness may encourage activity and emissions to shift to jurisdictions without a carbon price, making the carbon pricing policy environmentally ineffective. These arguments have achieved resonance in both policy and public debates. Despite the importance that this issue has been given in public and policy debates, empirical evidence of the existence of carbon leakage has proven to be limited.

The purpose of this report is to draw lessons from policy-making experience and academic evidence to provide guidance to countries on how to address issues of leakage as they arise in their national contexts. Policy makers have developed a range of approaches to addressing these concerns, in light of their particular economic and social circumstances. Despite the variety that has arisen in response to these contextual factors, there is scope to learn from past policy-making experience and academic evidence in the future implementation of similar measures.

1.3. Report Structure

This report is structured into five further sections:

- section 2 introduces the concept of carbon leakage and explains how it relates to the context of developing and harmonizing carbon pricing policies;
- section 3 examines the theory and evidence of carbon leakage;
- section 4 explores how to determine which firms and sectors are at risk of carbon leakage and how to target leakage prevention measures;
- section 5 discusses the different policy options available to address carbon leakage; and
- section 6 discusses stakeholder engagement on carbon leakage.

Details of the findings of consultation with policy makers and independent experts are outlined in Appendix 1. Appendix 2 discusses the interrelationship of national competitiveness and the competitiveness of particular firms or sectors.

2. Carbon Pricing and Carbon Leakage

This section provides an introduction to the concept of carbon leakage and places it within the context of the broader discussions around both climate policy and competitiveness. Specifically:

- section 2.1 briefly outlines some of the key arguments in favor of carbon pricing;
- section 2.2 identifies that, while carbon pricing schemes are growing in reach, there is unlikely to be a global carbon price any time in the near future, and discusses the challenges this creates for policy makers in terms of carbon leakage;
- section 2.3 explores the links between carbon leakage and broader discussions surrounding firm, sector, and national competitiveness.

2.1. The Objective of Carbon Pricing Policy

Deep decarbonization of the global economy requires broad-based reductions in greenhouse gas emissions across a range of countries and sectors. In 2012 over 80 percent of the world's primary energy supply was from fossil fuels. In addition, a range of important production processes result in greenhouse gas emissions, including manufacture of cement, metals, and chemicals, livestock raising, rice cultivation, logging, and waste management. Such a broad-based challenge requires a broad-based solution. The substantial mitigation effort required to meet ambitious climate targets such as stabilization at 450 parts per million of carbon dioxide equivalent (CO₂e) will not be possible without action in all major emitting countries and across a range of economic sectors. The authors of one integrated modeling exercise described the mitigation challenge as follows (Clarke et al., 2009):

failure to develop a comprehensive, international approach to climate mitigation will constrain efforts to meet ambitious climate-related targets ... regardless of the target, the global costs of achieving any long-term climate related target will be higher without comprehensive action.

This will necessitate significant, economically efficient, structural change. Substantial technological change and investment is required to produce important goods and services such as electricity, steel, cement, chemicals, transportation, and agricultural commodities in a less emissions-intensive way. Inducing this change requires a deliberate policy of increasing the financial costs associated with emissions-intensive activities that impose climate change damage on society, and decreasing the costs of those activities that do not. This is an economically efficient outcome which levels the playing field between polluting and clean firms. Indeed, the absence of such policies can be thought of as providing a *subsidy* for "dirty" production (Helm, Hepburn, & Ruta, 2012).

Achieving this structural change cost effectively is unlikely to be feasible through direct government regulation. The future path of technological development, fuel prices, demand trends, and a range of other factors that affect abatement effort is inherently uncertain. Actions are required across a range of economic sectors with varying regulatory and market structures. Abatement actions may range from obvious and intentional, such as adopting renewable energy in place of fossil fuel energy, to unintentional,

such as the movement of people or relocation of economic activity. Given this complexity, governments are unlikely to have sufficient information to be able to establish rules quickly enough to feasibly capture the lowest-cost abatement options.

Because carbon pricing is flexible and works through a number of channels, it is likely to be a critical policy tool to drive the required structural change at low cost. A carbon price will increase the cost of producing emissions-intensive goods and services which will motivate end-users to reduce consumption and/or switch toward lower-emissions alternatives. It will also cause firms to reduce their emissions to improve profitability: like any other business cost, if a firm can reduce its emissions, and therefore its carbon emission costs, more than its competitors, it will be likely to gain market share and/or increase its profit margin. Over time, therefore, carbon pricing will ensure that relatively emissions-intensive (“dirty”) producers lose market share to lower-emissions (“cleaner”) competitors. Carbon pricing can also promote innovation by improving the expected returns to developers of low-carbon technologies. Furthermore, these benefits are realized in a decentralized way rather than according to the direction of a prescriptive government regulation, meaning that carbon pricing will promote cheaper abatement options over more expensive ones, a finding that has been supported by empirical analysis (OECD, 2013a). Accordingly, such approaches are likely to be a critical part of the world’s response to the need for decarbonization.

2.2. The Challenge of Incomplete Carbon Pricing

The most cost-effective emissions reduction policy would be a globally harmonized carbon pricing regime that imposes a uniform cost on emissions across all major emitting countries and sectors. In theory such a regime could be achieved by either coordinated national carbon taxes or linked emissions trading schemes. At present, the latter option appears more practical as it could be achieved by multiple emissions trading schemes recognizing permits and the associated right to pollute issued under other schemes but, in principle, multiple countries could agree on setting a minimum carbon tax rate. Either approach would allow emissions reductions to occur in whichever country they are most efficient, promoting a lower-cost global approach to abatement.

While harmonized carbon pricing may be the ideal, political realities dictate that individual approaches at the national and subnational level are inevitable. Individual governments must lead on establishing carbon pricing policies within their relevant jurisdictions. Establishing carbon pricing policies requires both supporting technical regimes, such as emissions measurement and verification, and substantial political debate in the relevant jurisdictions. These processes are time-consuming and complex even at a national or subnational level; attempting to coordinate them across multiple jurisdictions in the context of a high-profile and important policy change is infeasible for the foreseeable future. Arguments over the distribution of abatement efforts across different jurisdictions further complicate multilateral emissions reduction policy development and reinforce the primacy of carbon pricing policymaking at the national or subnational level.

The number of governments that have introduced carbon pricing is growing. Around 40 countries and over 20 subnational jurisdictions are putting a price on carbon, including the 28 nations of the EU, California, Quebec, Republic of Korea, New Zealand, and a range of cities and provinces in China

(World Bank Group, 2015). There are also some moves toward harmonization of carbon pricing through the linking of emissions trading schemes across multiple jurisdictions, such as between California and Quebec, as well as between the EU ETS and schemes in Norway, Iceland, and Liechtenstein, although many policies remain fragmented along national or subnational boundaries.

However, so long as some countries and regions do not introduce comparable policies², the issue of carbon leakage may arise. Carbon leakage occurs when an emissions reduction policy, such as a carbon price, causes a reduction in emissions in the jurisdiction where it is implemented but inadvertently causes an increase in emissions in other jurisdictions that do not have equivalent emissions reduction policies. This increase in emissions in other jurisdictions arises because the difference in policy can cause production to shift. If the emissions intensity of production in jurisdictions that see an increase in production is greater than in jurisdictions where production falls, it is conceivable that this could lead to a net increase in global emissions. As the European Commission (2015) states:

carbon leakage is the term often used to describe the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries which have laxer constraints on greenhouse gas emissions. This could lead to an increase in their total emissions.

Carbon leakage could present a combination of undesirable environmental, economic, and political outcomes for policy makers. Carbon leakage could undermine a carbon pricing policy's environmental objective by causing emissions to increase in jurisdictions beyond the reach of the policy. This also implies that the economic cost of meeting a given emission reduction objective increases. At the same time, the decline in domestic production and, hence, possibly, employment can create significant political challenges. This confluence of potentially undesirable environmental, economic, and political outcomes means that the issue of leakage is always one of the most controversial and important aspects when considering the design of carbon pricing mechanisms.

2.3. Competitiveness and Leakage

Carbon leakage is caused by competing firms facing different carbon emission costs and so is often closely related to the issue of cost competitiveness. At the level of an individual firm or sector, competitiveness refers to the ability of firms to maintain or increase international market share in an undistorted market environment. A key component of competitiveness for many emissions-intensive firms/sectors is the cost of production: while competitiveness can be driven by a range of factors, such as innovation, to deliver new products, to understand and shape consumer preferences, and to develop brand loyalty³, such factors are typically less important than production costs for many emissions-intensive products. This reflects the

² Typically, equivalent policies are considered in terms of the introduction of an explicit carbon price in one jurisdiction and whether or not there is an equivalent explicit carbon price in other jurisdictions. However, as discussed further below, a range of policies—such as regulations demanding use of a particular technology—can also have an effective carbon price associated with them that, in principle, at least, should be taken into account when considering whether policies are comparable. See OECD (2013a), Productivity Commission (Australia) (2011) and Vivid Economics (2010).

³ See, for instance, the five forces frameworks created by Porter (1979).

limited scope for product differentiation or potential to fundamentally change the quality or nature of the end product of most carbon-intensive goods.

However, it is important to distinguish competitiveness from competition interactions. The concept of competitiveness relates to how effective firms can gain market share in an *undistorted* market environment. It is generally recognized that input subsidies or other trade distortions can allow recipient firms to gain international market share and improve profits in the short term while simultaneously harming their long-run international competitiveness (by, for instance, reducing the incentives that they have to seek out cost savings). Carbon pricing can be seen through the same lens: while the absence of a domestic carbon price may allow firms to benefit in the short run, it may weaken their competitive position in the medium-to-long run as they are less well positioned to compete in a market environment in which carbon emissions are constrained.

Even if there is a focus on the short-term cost impacts of the carbon pricing, the cost impact of carbon pricing and the associated risk of carbon leakage must be seen in the context of a range of other business costs. A range of other energy and nonenergy input costs will be important in determining production decisions. In the long run, investment decisions will be influenced by a wide range of factors, such as proximity to product markets and low-cost inputs, construction costs for new facilities, transport costs for reaching key markets, as well as overall business risks as might be captured in firms' cost of capital⁴. Overall, carbon emission costs will be only one factor among many driving production and investment decisions, even in emissions-intensive sectors. It is notable, for instance, that survey studies of firms on the impact of carbon policies on competitiveness often cite other factors as more influential, such as changes in input costs like labor (Sartor & Spencer, 2013).

National competitiveness, to the extent that it is a meaningful term, is unlikely to be affected by carbon pricing. While the concept of cost competitiveness can be understood at the level of a firm or sector, the extension of this concept to the economy-wide level is more elusive. It is increasingly recognized that, to a significant extent, at a national level competitiveness is similar to the concept of productivity—in other words, the value of the goods and services that are produced in the economy for a given set of labor and capital inputs. In turn, this is largely recognized as being driven by factors such as the overall quality of institutions, education levels, the existence of efficient labor and financial markets, and the quality of the business environment. In this view, in the vast majority of countries, the cost of complying with environmental regulation is likely to be of minor importance. The interrelationship of national competitiveness, and the competitiveness of particular firms or sectors, is discussed further in Appendix 2.

⁴ Many of the factors influencing the overall business risks faced by firms in a particular location are captured in indicators such as the World Bank Ease of Doing Business ranking (World Bank Group, 2014a).

3. Theory and Evidence of Carbon Leakage

Carbon Leakage Has Been Examined Extensively through Both Theoretical and Empirical Studies

Carbon leakage has been extensively discussed and modeled but remains politically contentious and analytically difficult to isolate and quantify. This section addresses these complexities by:

- defining leakage and identifying its key channels (section 3.1);
- comparing the key theoretical approaches to modeling leakage and assessing the impacts of carbon pricing on exposed sectors against the broader economic effects (section 3.2); and
- examining the empirical evidence of carbon leakage from historical studies of carbon-pricing policies (section 3.3).

These sectors will assist in framing the subsequent discussion of policy options to address leakage in sections 4 and 5.

3.1. Defining Leakage and Identifying Its Key Channels

As explored above, leakage refers to the transfer of production—and hence emissions—from one jurisdiction to another as a result of differences in the stringency of carbon regulation. A crucial component of this definition is that carbon leakage should be assessed by considering what may happen (or might have happened) as result of differences in carbon regulation that would not (have) happen(ed) if there were equivalent carbon regulation across all countries. This is different from simply observing changes in emissions or output over time. As stressed above, a multitude of factors can affect operating and investment decisions in industries and hence their emissions levels: carbon leakage arises only if those changes in emissions can be attributed to the introduction of, or change in, carbon-pricing policy, and if there is a corresponding increase in production in other jurisdictions. For instance, the closure of a plant after the introduction of a carbon price can be thought of as an example of carbon leakage only if it would have continued operating had the carbon pricing policy not been introduced and if there is also an increase in production in other jurisdictions that would not otherwise have occurred.

Carbon leakage can arise through four channels. These are:

- the output or short-term competitiveness channel;
- the investment or long-term competitiveness channel;
- the fossil fuel price channel; and
- reverse leakage through the technological spillovers channel.

- 1. The output or short-term competitiveness channel operates through distorted output decisions.** Higher carbon emission costs can cause firms affected by carbon pricing (covered firms) to lose market share to the benefit of those not covered by carbon pricing (uncovered firms) (Reinaud, 2008). This in turn will lead to carbon leakage. It should be stressed that while individual firms in

jurisdictions introducing a carbon price may lose market share as a result of that carbon price, this will lead to carbon leakage only if their lost output is replaced by uncovered firms. If the output is replaced by other covered firms, because they are less carbon intensive, emissions in jurisdictions without a carbon price will not increase and no leakage will occur. Indeed, this is part of the intended effect of the policy.

- 2. The investment or long-term competitiveness channel operates in the medium-to-long term if different carbon prices alter investment decisions between countries.** In the medium term this can occur through reduced investment in maintenance capital to sustain output levels from covered firms. This would lead to reduced efficiency and/or reliability, in turn potentially resulting in reduced output in the medium term, which could be taken up by uncovered firms. In the longer run, existing plants in jurisdictions with more stringent carbon regulation may close and/or new plants may be preferentially located in jurisdictions with less stringent carbon regulation due to lower costs and consequently higher returns on capital. However, as noted in section 2.3, it is crucial to recognize that major investment decisions are based on multiple factors, of which carbon policy is only one; changes in exchange rates, labor and capital costs, proximity to market, other taxes, as well as factors like the quality of institutions and infrastructure (often embedded in the firm's cost of capital) are, in many cases, far more significant in a company's decision than the existence of a carbon price (Reinaud, 2008). Given these multiple factors, it can be particularly challenging to determine the true rate of leakage occurring through this channel (Vivid Economics, 2014).
- 3. The fossil fuel price channel exists because firms in jurisdictions with more stringent carbon regulation are likely to reduce fuel use in response to that regulation, which can reduce the price of globally traded fossil fuels.** These reductions in global energy prices would be expected to increase demand for these fuels in jurisdictions with less stringent regulations. This, in turn, will increase emissions in these jurisdictions, resulting in carbon leakage.
- 4. The technological spill overs channel may mean that carbon regulation results in reverse leakage by spurring innovation in jurisdictions with a carbon regulation, leading to reduced output and emissions in jurisdictions without a carbon price.** Stringent climate policies could stimulate technology development and innovation, improving the international competitiveness of firms affected by the carbon price (Droge, Grubb, & Counsell, 2009). Broadly speaking, this is similar to the "Porter hypothesis" that environmental regulation can lead to unexpected improvements in firm competitiveness. This might lead to a decrease in global emissions if new low-carbon technologies become the most cost-effective production method, with firms in the stringent climate policy regions gaining international market share. The reduction in output and emissions in jurisdictions with less stringent carbon regulation would result in negative leakage, all other things equal.

The primary concerns of policy makers are typically the first and second channels; these channels are the main focus of this analysis. The short-term competitiveness and investment channels have, in theory, the potential to lead to both perverse emissions outcomes and to distort patterns of output; these are the concerns that have typically motivated policy makers to address carbon leakage when introducing carbon-pricing regimes. While the fossil fuel price channel can lead to similarly undesirable

outcomes, it is harder to directly target through policy due to the complex determinants of global fossil fuel prices. It is also not a leakage channel where there is a corresponding distortion in competition. Accordingly this channel has not typically been a focus of policy makers. The fourth channel is a potential positive effect of carbon-pricing regimes and works to reduce leakage, and so is not a focus of policy efforts to avoid leakage. However, it highlights the potential complementary role of technology development in promoting emissions reductions while minimizing unwanted economic effects, which is discussed further in section 5.4.

Carbon leakage is typically thought of in the context of explicit carbon prices, and this is the focus of this study, but could equally occur due to costs associated with implicit carbon prices imposed by other means. Explicit carbon pricing includes instruments such as emissions trading schemes or carbon taxes. However, even if countries do not have explicit carbon prices, they often implement some form of climate policy that has a “shadow” carbon price (Marcu, Leader, & Roth, 2014; OECD, 2013a; Productivity Commission (Australia), 2011; Vivid Economics, 2010), such as renewable energy targets and plant emissions standards, while fuel taxes also effectively imply some form of effective carbon price (OECD, 2013b). If the costs imposed by this policy are sufficiently high and affect firms facing competition from outside the scope of the policy they could create concerns about carbon leakage. For example, such concerns were raised by stakeholders in the context of Australia’s expansion of its renewable energy target in 2009 on the grounds that it would increase costs and reduce the competitiveness of energy-intensive trade-exposed firms such as aluminum smelters. Likewise, energy-intensive industries in Germany are not required to pay as large a surcharge to support renewable power development as other electricity consumers in the country so as to prevent carbon leakage.

When considering carbon leakage it is important to consider both the direct and the indirect carbon emission costs faced by firms. Direct carbon emission costs will be proportional to the direct emissions resulting from a production process. In addition, firms can face indirect carbon emission costs when suppliers of inputs to their production process themselves face carbon emission costs, and are able to pass a portion of those costs on to the purchaser of the input. An important source of indirect carbon emission costs for many businesses is electricity, but cost increases from other emissions-intensive inputs are also possible.

It can sometimes be helpful to define a carbon leakage rate in terms of the increase in emissions in the jurisdiction without a carbon price (or with a lower carbon price/less stringent regulation) expressed as a percentage of the decrease in emissions in the jurisdiction with a (higher) carbon price (or more stringent regulation)⁵. For instance, if the introduction (or further strengthening) of carbon pricing resulted in total carbon emissions in one country declining by 200 tones and foreign emissions increasing by 60 tones, the leakage rate would be calculated as 60 divided by 200, and expressed as 30 percent. Carbon leakage rates can exceed 100 percent in cases where the increase in production from

⁵ For simplicity, we subsequently refer to carbon leakage in the context of jurisdictions introducing carbon prices when other jurisdictions do not have carbon prices. However, identical dynamics can emerge if jurisdictions make their carbon-pricing policy more stringent when other regions do not have carbon prices or have lower carbon prices. This is discussed further below.

firms without a carbon price is more emissions-intensive than the production reductions from those affected by carbon pricing. Carbon leakage rates can also be negative if emissions fall in jurisdictions without a carbon price. However, these are extreme cases; typically one would expect carbon leakage rates to be between zero and 100 percent. While policy makers will not always need to rely on formal estimates of carbon leakage rates to set policy (especially because, as described in section 3.2 below, such numbers can be sensitive to different modeling assumptions), they can nonetheless be a useful analytical tool to understand differences between sectors, over time, or between different modeling analyses.

In cases where carbon leakage rates are estimated, it is necessary to formally make assumptions as to which countries have strict and lax carbon regulation. By definition, leakage is the increase in emissions in jurisdictions with lax carbon regulation (or with no carbon price) divided by the decrease in emissions from firms in jurisdictions with stringent carbon regulation (or with a carbon price). However, it is often a simplification to split jurisdictions into two categories for at least two reasons:

- it ignores the potential for variation in the stringency of different carbon pricing policies;
- as noted above, it is likely to ignore the fact that most jurisdictions impose implicit carbon prices through other policies.

However, making adjustments to leakage calculations to account for these factors is likely to be complex and contentious. Therefore, in practice, for the purpose of measuring leakage rates analysts tend to apply simple judgments to define which jurisdictions have or do not have a carbon price (strict carbon regulation), an approach which we reflect below. While this binary approach is somewhat less robust, it has the merit of being more transparent than applying complex weightings based on the assessed ambition of a variety of policies in each jurisdiction.

3.2. Modeling Leakage and Other Effects of Carbon Pricing Policies

Policy makers can use modeling analysis as one tool to help understand the risk of leakage across different sectors. Gaining an understanding of carbon leakage risk is important for policy makers when deciding whether to introduce or tighten carbon pricing and may also inform their policy response (see sections 4 and 5). This assessment can in part be informed by the judgment of experts or politicians, although modeling approaches can often play an important role, especially as this can aid the transparency of any subsequent decisions.

Modeling leakage can involve either a theoretical approach that models both “with policy” and “without policy” scenarios or a historical empirical approach using real, historical world data and an estimated counterfactual. Under each approach the modeling framework must account for the interaction of carbon pricing with a range of other economic variables, such as demand and prices of other inputs, to build an understanding of the world with and without the relevant policy. The former approach is sometimes referred to as an “ex ante” or theoretical approach as it can use theoretical simulated outcomes to estimate the effect of the carbon price in the future without direct reliance on historical data. As policy makers are generally interested in assessing the potential effects of policy in advance of its introduction, approaches to making “ex ante” assessments of leakage are likely to

be of particular interest. These are discussed further in section 3.2.1 below. The latter approach is sometimes referred to as the “ex post” approach because it relies on analysis of outcomes after the event. Use of this approach to identify evidence of carbon leakage is discussed further in section 3.2.2. This analysis is also very useful for policy makers as they seek to review the effectiveness of and refine policy over time.

3.2.1. Ex ante Estimates of Leakage: General and Partial Equilibrium Options

There are two primary subtypes of the ex-ante approach to modeling carbon leakage: general equilibrium and partial equilibrium approaches. The first approach uses large-scale computable general equilibrium (CGE) models that capture and highlight the effect of climate policy on energy and factor market prices, and thereby on production and emissions outcomes. The second approach examines carbon leakage by modeling detailed output and emissions patterns at the level of an individual sector in which only a subset of firms faces a carbon price (or another form of carbon policy), but ignores the interaction of that sector with the wider economy.

Typically, both types of model involve the development of a baseline or reference scenario which depicts an understanding of how the economy or sector is anticipated to develop in the absence of asymmetric carbon pricing policies (e.g., where no jurisdiction has a carbon price). The model is then run again with the impact of the asymmetric carbon price included (e.g., where one jurisdiction introduces a carbon price and others do not). The difference between the two scenarios can then be attributed to the asymmetric carbon pricing policy with increases in emissions in other jurisdictions not seen in the reference scenario used as an estimate of the carbon leakage. This approach is consistent with the concept of a leakage rate discussed in section 3.1 above. A third scenario might be run where all jurisdictions introduce the same carbon price to determine if any of the carbon leakage is efficient. Depending on the sophistication of the modeling approach, further modeling runs can be used to estimate the impact of different types of leakage prevention mechanisms.

Both types of models can provide insights on a wide range of variables of interest: our focus is on what they suggest regarding leakage. As well as estimating leakage rates, CGE models can provide estimates of the overall expected welfare impact of carbon pricing (often measured in terms of output), which can be of considerable interest to policy makers. Box.1 provides more information on some of these other insights that can be captured through CGE models. Partial equilibrium models often allow for the competitive dynamics between different producers in the market to be explored, or cost pass-through rates to be estimated, also of significant policy interest.

A key advantage of general equilibrium modeling is that it places leakage in the context of the broader effects of a carbon pricing policy. The whole-economy perspective of CGE modeling allows it to capture the indirect, feedback effects that might be relevant to sectors affected by a carbon price, for instance how the carbon price may lead to the reallocation of resources between economic sectors as input prices change. These indirect impacts can be particularly important when the carbon-pricing mechanism envisages recycling of any revenues that are raised by carbon pricing to different sectors of the economy. By contrast, partial equilibrium approaches focus only on a subset of sectors and cannot capture indirect, feedback effects resulting from carbon pricing.

Box 1. Modeled Welfare Impacts of Carbon Pricing Policies

General equilibrium models suggest that the welfare effects of carbon pricing are typically modest. For example, across 25 CGE models, the estimates of the impact on welfare (usually proxied for by output or GDP) of the unilaterally acting countries range from –1.58 percent to 0.02 percent (see meta-analysis by Branger & Quirion, 2013). To facilitate comparisons of different policy measures, these welfare impacts do not account for the environmental benefits of lower global greenhouse gas emissions. In any case, seen relative to the size of countries' overall economies, these welfare impacts are quite low, even in cases where leakage is relatively high. Partial equilibrium models are typically not able to provide global welfare estimates.

Technology development benefits from climate policy are often not captured in general equilibrium modeling approaches and hence in these welfare estimates, although an increasing number of CGE models are trying to incorporate these effects. If carbon pricing induces a domestic firm to introduce a new, cleaner product, the benefits from this will typically not be captured by existing modeling approaches. However, recent CGE modeling approaches incorporate this effect (see McKibbin & Wilcoxon, 2009, and Gerlagh & Kuik, 2014). Failure to incorporate these benefits will overstate the negative welfare impacts of climate policy and ignore the potential broader economic benefits of innovation. More generally, studies show that climate policy can encourage innovation. For example, Cael and Dechezlepretre (forthcoming) examine the impact of the EU ETS on European patent data and find that carbon pricing induced up to a 10 percent increase in low-carbon innovation by affected firms, with little discernible effect on those not affected by the carbon price. Such technological progress can form an important benefit from carbon pricing, in addition to the standard cost-effectiveness arguments.

On the other hand, the aggregated level of modeling in the general equilibrium approach cannot capture some aspects of market structure and competitive dynamics as well as partial equilibrium approaches. CGE models do not account for the details of market structure and how it may vary across different sectors in the economy, especially emissions-intensive sectors. Moreover, to maintain tractability, these models typically assume that individual markets are perfectly competitive. While this is a reasonable assumption for some sectors, it is often empirically implausible for highly emissions-intensive sectors such as electricity and cement. By contrast, partial equilibrium models usually provide greater empirical realism in terms of the model assumptions and inputs, especially by allowing for imperfect competition. They also allow for carbon leakage to be compared across different sectors, in a way that can help identify what sectoral characteristics are driving leakage rates at a more granular level.

There are striking differences in estimates of carbon leakage rates across the two approaches, with the range of results reflecting large uncertainty in leakage rates. In CGE models leakage rates tend to be low, typically in a range of around 5 to 15 percent, although results are not conclusive of the existence of leakage⁶. By contrast, the range of leakage estimates from partial equilibrium models is much wider, suggesting possible leakage rates between 0–100 percent, depending on assumptions and model specification. These suggest large uncertainty in possible leakage rates. The variation in results is presented in Table 1.

⁶ One key exception to this in the literature is Babiker (2005), which estimates a leakage rate as high as 130 percent as a result of increasing returns to scale production technologies, leading to oligopolistic market structures.

Table 1. General and Partial Equilibrium Approaches Demonstrate a Clear Difference in Predicted Leakage Rates

<i>Author(s)</i>	<i>Period covered</i>	<i>Sector and geography</i>	<i>Carbon prices, per tCO₂</i>	<i>Modeled carbon leakage rates, percent (direction of leakage)</i>
General equilibrium (CGE)				
Babiker (2005)	2010	Global; 7 commodities	No explicit price	50 to 130 (OECD to non-OECD)
Baylis et al. (2014)	2010 data	Global, multisector	No explicit price	10 to 15; falling to –8.5 to 3 with abatement resource effect (countries not indicated)
Burniaux & Martins (2000)	Pre-EU ETS; 1996–99	Global international coal market	A range of carbon prices are considered, but no explicit values are given	2 to 27 (from Annex 1 to non-Annex)
Carbone (2013)	1995–2011	Global (leakage from Annex 1 to non-Annex); 112 regions; 57 sectors	No explicit carbon tax considered, but tax is set so as to reduce emissions generation by 20%	–9 to 28 (Annex 1 to non-Annex 1)
Caron (2012)	1995–2008	Global; 51 sectors	US\$41 to US\$55	1 to 17 (an unspecified subset of countries)
Gerlagh & Kuik (2007)	1999–2005	Global; energy-intensive goods	Carbon prices are determined by the model so that countries achieve their emissions reductions target as in Kyoto Protocol statements	–17 to 17 (Annex 1 to non-Annex 1)
Kiula, Wójtowicz, Żylicz, & Kasek (2014)	To 2020	Global, multisector	Ranging from US\$197 to US\$21 for EU and ranging from US\$20 to 32 for non-EU	0 to 28 (EU to ROW)
Kuik & Gerlagh (2003)	Kyoto Protocol; 1995 trade and production statistics	OECD; GTAP economy-wide dataset	Endogenous calculation of carbon tax required for various regions to reach their emissions targets: for the US, US\$3.5; for Japan, US\$28; for the EU: US\$17; other OECD, US\$24	11 to 15 (Annex 1 to non-Annex 1)
Kuik & Hofkes (2010)	data calibrated to 2001–06	Global; mineral sector	€20	17 to 33 (EU to ROW)
Lanzi, Mullaly, Chateau, & Dellink (2013)	Calibrated to 2013–20	Global, multisector	Ranging from US\$12 to US\$163 for Annex 1 countries; US\$0 for non-Annex 1	9 (Annex 1 to non-Annex 1)

Table continues next page

Table 1. General and Partial Equilibrium Approaches Demonstrate a Clear Difference in Predicted Leakage Rates (*continued*)

<i>Author(s)</i>	<i>Period covered</i>	<i>Sector and geography</i>	<i>Carbon prices, per tCO₂</i>	<i>Modeled carbon leakage rates, percent (direction of leakage)</i>
Monjon & Quirion (2009)	Calibration year 2005	Global; multisector	€14 to €27	5 to 12 (EU to ROW)
Paroussos, Fragkos, Capros, & Fragkiadakis (2014)	2015–2050	Global, multisector	Ranging from US\$14 in 2020 rising to US\$148 in 2050 for the EU; ranging from US\$0 to 15 for China; ranging from US\$0 to US\$78 for the US	28 (EU to ROW) to 25 (EU + US to ROW) to 3 (EU + US + China to ROW)
Partial equilibrium				
Allewi, Oggioni, Riccardi, & Rocco (2013)	NA	EU ETS-covered part of cement (clinker) in Italy	Ranging from €32 to €100	17 to 100 (Italy to ROW)
Demaiily & Quirion (2006)	Projections from 2008–12; policy calibrated to 2004	Global; focuses on cement	€20	0 to 50 (EU to ROW)
Droge, Grubb & Counsell (2009)	Projections to 2013–20	Electricity, steel, cement, and aluminum; draws on studies focusing on these industries in the UK, US, Poland, and the EU	€14	0 to 39 (EU to ROW)
Healy, Quirion, & Schumacher (2012)	2005–12	EU; grey clinker market	€20	22 (EU to ROW)
Ponsard & Walker (2008)	1995–2007; production data calibrated to 2006	Cement in a “typical Western European country market”	€50	70 to 73 (not specified)
Ritz (2009)	Ex ante; market data for 2004; parameters calibrated using data between 2003 and 2005	Focuses on EU ETS-covered steel	€20	9 to 75 (EU to ROW)

Table continues next page

Table 1. General and Partial Equilibrium Approaches Demonstrate a Clear Difference in Predicted Leakage Rates (*continued*)

<i>Author(s)</i>	<i>Period covered</i>	<i>Sector and geography</i>	<i>Carbon prices, per tCO₂</i>	<i>Modeled carbon leakage rates, percent (direction of leakage)</i>
Santamaría, Linares, & Pintos (2014)	2005–14	EU ETS-covered part of cement, steel, and oil refining in Spain	Ranging from €5 to €35	35 to 80 for cement, 18 to 95 for steel, 10 to 90 for oil (Spain to ROW)
Szabó, Hidalgo, Ciscar, & Soria (2006)	1990–97	EU and Kyoto Protocol Annex B countries; cement	Ranging from €28 to €40	Carbon leakage: 29; production leakage: 33 (EU and Annex B countries to ROW)
Vivid Economics (2014)	Projections to 2013–20	Models impact of Phase III of EU ETS on 25 UK industries	Ranging from €5 to €50	Rates of 0 to 100 by 2020 depending on the sector (UK to ROW)

Source: Vivid Economics

Note: Kiulla, Wójtowicz, Żylicz, & Kasek (2014) results reported using a common definition of leakage for comparability with other studies, rather than the authors' preferred definition

While the differences in leakage rates between general and partial equilibrium approaches have not been resolved in the literature, there are several plausible potential explanations. One consideration is that a comparison of leakage rates between an economy-wide figure from a CGE model and a sector-specific rate from a partial equilibrium analysis is not like-for-like. In particular, the partial equilibrium results, by construction, typically focus on an exposed sector, while the CGE result typically aggregates across many sectors, some of which are exposed and some are not. For example, the domestic electricity sector is a large source of emissions reductions but, in many countries, it has little or no trade exposure, and thus little or no leakage, which dilutes the leakage rate modeled across an economy using CGE. A further explanation is that while CGE models typically assume that firms are price takers, they do not take domestic and foreign firms' products to be perfect substitutes. In particular, they use trade elasticities to calibrate the degree of substitution, and these elasticities imply that firms' products are, in effect, quite strongly differentiated. By contrast, in partial equilibrium approaches, products are often assumed to be perfectly homogeneous and interchangeable from a buyer's point of view, irrespective of whether they are imported. Unless transport costs are prohibitive, this creates strong substitutability and competitive pressure between producers in different jurisdictions.

There are also important differences in the results observed within each category of model. Some of the key drivers for this are explored in Box 2 below. Model results are sensitive to inputs and assumptions that can be selected to support particular outcomes. Careful consideration should be given to these inputs and assumptions when comparing model results. Similarly, careful consideration should be given to the inputs, assumptions, and scenarios before using results from existing modeling exercises to inform new policy development.

Box 2. Variations in Key Assumptions Cause Leakage Rate Estimates to Vary between Studies Using Similar Approaches

The underlying assumptions used to calibrate both general and partial equilibrium models are key drivers behind the variation in results achieved within each approach. In terms of general equilibrium modeling, studies' findings have been found to be particularly sensitive to the choice of:

- Armington elasticities: in CGE models, these are parameters which estimate the degree to which internationally traded goods are substitutable between economies.
- Substitutability between factor inputs in the production process: in the context of analyzing leakage, this generally relates to the substitutability between energy and nonenergy factors of production.
- Elasticity of fossil fuel supply: allowing for a greater elasticity in fossil fuel supply, and thus assuming that regulated economies can switch to cleaner technologies, can lead to lower leakage rates in terms of global emissions; reductions in regulated economies are greater in magnitude than emissions increases in unregulated economies (Carbone, 2013)

As a result of the sensitivities of models to underlying assumptions, authors tend to present a range of estimates based on how the model is calibrated. As reported in Table 1 above, Burniaux & Martins (2000) estimate a range of leakage rates from 2 to 27 percent. This range is driven by the assumptions regarding trade and substitution elasticities. Their low-end estimate is derived from setting the trade substitution elasticities for coal at 0.5, setting the supply elasticity of coal at (downward) infinity and the supply elasticity of oil at 2. By contrast, their high-end estimate of 27 percent is derived by setting the trade substitution elasticity for coal at 2, the supply elasticity of coal at 0.1, and the supply elasticity of oil at 0.5.

In partial equilibrium models, an “off-model” assumption is normally made as to the geographic locus of competition—in other words, to the location of competitors and the proportion of market supply that is affected by the carbon price. For example, Smale, Hartley, Hepburn, Ward, & Grubb (2006) consider the impact of the EU ETS in five markets: grey cement, newsprint, refined products, cold-rolled flat steel, and primary aluminum. In their analysis, the cement market is considered national; newsprint, refined products and cold-rolled flat steel as regional; and aluminum as global. They find that the impact of carbon pricing on European aluminum output levels (and hence, it may be assumed, leakage risk) is higher than for the other markets studied because the assumed market definition means that only a small proportion of production in the aluminum market (global) is affected by the carbon price, whereas, in the other markets studied (national and regional) a greater proportion of production is affected by the carbon price.

While the outcomes of partial and general equilibrium approaches are somewhat difficult to reconcile, their different strengths and focuses make both approaches valuable to modeling leakage, and they should ideally be used in combination. As they are able to target different and important elements of the issue, using both approaches allows the granular nature of partial equilibrium estimates at the sectoral level to be combined with the general equilibrium effects of fuel price changes and resource reallocation across the economy. Where feasible, a combination of both approaches is ideal, with partial equilibrium outputs feeding into general equilibrium models and, in turn, being informed by general equilibrium outcomes. However, a clear drawback of such an approach is the time and modeling effort associated with iterating models, and the potential difficulty in achieving consistency between results from the two approaches. In the absence of a combined approach, general and partial equilibrium results may be more easily reconciled by separately reporting sector-level results from general equilibrium models to ensure a like-for-like comparison.

3.2.2. Ex Post Empirical Assessment of Leakage

While ex ante studies are useful to assess the potential effects of proposed policies, ex post empirical analysis of existing policies can help to draw on real-world experience to strengthen understanding of the risk of leakage and help to review appropriateness of policy over time. A common approach to ex post studies is to use econometric techniques to try to isolate the effect of the carbon pricing policy from other changes during the period of analysis. Another more qualitative approach is to use industry surveys.

Empirical examinations tend to find limited evidence of carbon leakage. These empirical studies typically use econometric techniques to examine historical effects of carbon pricing policies on output and emissions patterns while controlling for other influential factors. Other approaches utilize company-level data from affected sectors to examine the effects of carbon pricing on investment and company profitability. A summary of key empirical studies is provided in Table 2. As can be seen, most of these studies focus on the EU ETS as the longest established carbon pricing mechanism.

Table 2. Empirical Studies Provide Limited Evidence of Carbon Leakage

<i>Author(s)</i>	<i>Policy and period covered</i>	<i>Sector and geography</i>	<i>Strong evidence of leakage?</i>
Abrell, Zachmann, & Ndoye (2011)	Phases I and II of the EU ETS; 2005–08	Panel regressions; economy-wide coverage of the EU	No, but some sectors affected more than others
Barker, Mayer, Pollitt, & Lutz (2007)	Environmental (energy) taxes over period 1995–2005	Economy-wide coverage of six EU Member States	No
Chan, Li, & Zhang (2012)	EU ETS before and after implementation; 2001–09	Panel regressions covering power, cement, iron, and steel in the EU	No
Cummins (2012)	Phase I of the EU ETS	Panel regressions; economy-wide coverage of the EU	No
Ellerman, Convery, & Perthuis (2010)	Phase I of the EU ETS	Focuses on oil refining, aluminum, iron and steel, cement	No
Graichen et al. (2008)	Phase III of the EU ETS	Focuses on sectors in the EU ETS with more than three installations in Germany	No
Lacombe (2008)	Phase I EU ETS	Focuses on petroleum	No
Martin, Muûls, de Preux, & Wagner (2012)	Phases I and II of the EU ETS	Economy-wide; EU	No
Martin, Muûls, & Wagner (2011)	Phase I of the EU ETS up to 2009	800 companies in the EU ETS	No
Reinaud (2008)	Phase I of the EU ETS up to 2009	Covers steel, cement, aluminum, and refining in EU-25 Member States	No
Sartor (2012)	First 6.5 years of EU ETS	Focuses on aluminum	No
Sartor & Spencer (2013)	After introduction of EU ETS, anticipating Phase III; 1991–2010	Focuses on energy-intensive industries in Poland	No

Source: Vivid Economics.

These results are consistent with a recent review by the OECD of studies on the competitiveness impacts of carbon pricing. This review finds that empirical studies indicate that carbon pricing promotes abatement, but finds little evidence of negative competitiveness effects (Arlinghaus, 2015). Specifically, the study finds no causal effects of the EU ETS on output, profits, or trade outcomes, while employment reductions are mild and concentrated in nonmetallic minerals products.

Further supporting the broad conclusion that competitiveness effects are mild, two studies have failed to find evidence of within-country competitiveness impacts between firms that receive differential treatment under environmental policies. Flues & Lutz's (2015) econometric analysis compares German firms that did and did not receive support for the impact of higher electricity tax rates. The study found no difference between firms subject to the full tax rates and those receiving reduced rates in terms of turnover, exports, value added, investment, and employment. Their analysis suggests that the higher costs faced by the firms not receiving the reduced tax rates did not affect their competitiveness. Similar conclusions can be drawn from a study by Martin, Preux, & Wagner (2009), who found no difference in output or employment between firms that faced the full Climate Change Levy in the UK and those that received an 80 percent discount.

It is difficult to know for certain what explains the ex post modeling result of carbon leakage. While it could mean that the risk of leakage is negligible there are a number of other factors to consider.

- The accuracy of any econometric analysis depends largely on the amount of data available, which can be problematic given the short time frames many carbon pricing mechanisms, such as the EU ETS, have been in place (Vivid Economics, 2014). These time frames can be further shortened by contracting patterns in various sectors. For instance, the existence of long-term electricity contracts has also been a partial buffer to the impacts of the EU ETS (Varma et al., 2012; Sartor, 2013; Reinaud, 2008). Reinaud (2008) estimates that only 18 percent of capacity in the EU aluminum sector was exposed to higher electricity prices under the early years of the EU ETS, with the remainder protected, albeit temporarily.
- Operational schemes have typically been characterized by low carbon prices, which suggests that carbon prices may have had a smaller impact on production and investment decisions than a range of other factors, such as energy prices, raw material prices and changing international market conditions. Results could be different with higher carbon prices.
- Results could indicate that policy measures, such as free allowances and other measures to address leakage, have been effective. For example, in the EU ETS, the impact of carbon prices and risk of leakage may have been diluted by the free allowances available to industry in Phases I and II.

The empirical findings are, however, consistent with the analyses of the impacts of other environmental regulation on firm location and activity level. Ever since the 1970s they were also feared for causing the potential migration of industry to “pollution heavens” abroad, which has not materialized on a significant scale. This is briefly explored in Box 3 below. Environmental policies have even been found to induce innovation that offsets part of the cost of compliance with the environmental policy. This is not surprising for economists who have long observed that firms do not compete on costs only, but on the overall

Box 3. A Broader Literature on the Impact of Environmental Regulation on Firm Investment and Production Decisions Tends to Find Little Impact

Carbon leakage is a specific case of the general concept known as the “pollution haven hypothesis,” which states that polluting activities may be driven to jurisdictions with less stringent environmental regulations.

This argument has been advanced in relation to regulation on a range of pollutants, including air pollutants such as sulphur dioxide, nitrogen oxides, particulate matter or volatile organic compounds, various water pollutants, and regulation of solid wastes such as heavy metals.

Research has not provided conclusive evidence of the pollution haven hypothesis affecting investment and trade patterns. A number of studies in the 1990s examined trade pattern changes, greenfield plant locations, and industry migration based on differences in environmental regulation, and fail to find evidence that environmental regulations have had much impact. According to Jaffe, Peterson, Portney, & Stavins (1995), “there is relatively little evidence to support the hypothesis that environmental regulations have had a large adverse effect on competitiveness.” Other researchers have noted that environmental taxes are often relatively small and do not have a sufficiently large effect on unit costs to justify relocation to an unregulated jurisdiction (Barker, Meyer, Pollitt, & Lutz, 2007). An analysis of the effect of environmental regulations on energy- and non-energy-intensive industries in China indicated that firms shifted the composition of their production (in terms of capital and labor intensity) rather than the location, contradicting the pollution haven hypothesis (Zhu & Ruth, 2015). Finally, another study examining environmental policy in 21 European countries even suggests that higher environmental stringency is associated with increased, rather than decreased, investment levels (Leiter, Parolini, & Winner, 2011).

There are some contrary findings. Some studies criticize earlier work on the pollution haven hypothesis on methodological grounds, and find that increases in compliance costs do affect trade patterns and the location of heavy polluting industry. For example, Levinson (2009) estimates that a 1 percent increase in pollution abatement cost expenditures in the US is associated with a 0.4 percent increase in net imports from Mexico and a 0.6 percent increase from Canada.

efficiency of converting various inputs (including knowledge) into high-value products and services. Cost-competition is more important to sectors offering homogenous products and commodities.

Qualitative techniques, such as interviews with industry and policy-making stakeholders, surveys, and case studies, provide an alternative source of evidence on carbon leakage, but are subject to selection and reporting biases and inherent methodological weaknesses. While survey approaches usually limit the analyses to qualitative terms, some studies have performed regression analyses on the survey results in order to obtain quantified results. If questions are correctly phrased, surveys may be able to capture the degree to which carbon pricing has impacted investment and relocation decisions. However, surveys of this nature may be subject to selection and reporting biases, making their representativeness uncertain. A further complication is the difficulty of distinguishing between plant closures due to carbon policies and those which would have taken place regardless due to other market factors. For example, Cobb, Kenber, and Haugen (2009) report a view that carbon pricing had contributed to the closure of several aluminum smelters during the first six and a half years of the EU ETS, but this remains very difficult to substantiate.

These empirical challenges create difficult judgment calls for policy makers; it is difficult to determine whether leakage is low due to effective policy, because it is not a material concern, or because of other factors. As Karp (2010) observes, most non economists who have considered the question of leakage believe that it is important (in other words, that the risks of carbon leakage are significant). On the other hand, the weak empirical evidence, combined with modest rates of leakage in general equilibrium studies, gives some support to the view that leakage “will be small or moderate” (Karp, 2010). However, the higher rates of leakage in partial equilibrium studies, combined with the anecdotal concerns expressed by industry (Cobb, Kenber, & Haugen, 2009) and the political economy of lobbying, suggest that, on balance, leakage concerns will remain an important part of carbon pricing policy despite the generally weak evidence. Sections 4 and 5 consider in further detail the risks and benefits of policy action to reduce carbon leakage.

4. Policy Responses to Carbon Leakage: Which Sectors to Target?

Judicious Policy Choices Can Reduce Distortions and Save Scarce Fiscal Resources

In cases where policy makers are concerned that there is a substantial risk of leakage, they may decide to take action to reduce this risk. Such a policy may be seen as necessary to safeguard the environmental integrity and cost effectiveness of the carbon pricing regime, as well as in response to concerns from significantly affected firms and industries.

In terms of environmental integrity and cost effectiveness, the justification for establishing leakage prevention mechanisms is that some of the channels through which carbon pricing might be expected to reduce emissions under a globally harmonized carbon price may not materialize if only a few countries introduce carbon pricing. Broadly speaking, there are three main channels through which a global carbon price would be expected to reduce emissions that might be compromised in the absence of global harmonization.

- **Encouraging substitution from high-to low-carbon producers.** Under a globally harmonised carbon price all firms will face an equivalent carbon pricing regime with the intended effect that efficient producers will benefit more than less efficient ones. However, as discussed at length in the previous sections, without harmonization not all firms will face a carbon price, potentially distorting output patterns and resulting in carbon leakage.
- **Promoting demand-side abatement.** Under a globally harmonized carbon price the price of carbon-intensive goods and services will increase, prompting end-users to improve their efficiency. However, without harmonization, competition from producers that do not face a carbon price will tend to limit price rises and therefore reduce demand-side abatement.
- **Incentivizing firms to reduce their emissions intensity.** Under a globally harmonized carbon price lower emissions firms will gain a competitive advantage over higher emissions firms, allowing them to increase profit margins and/or market share. This will encourage firms to improve their emissions intensity. However, without harmonization firms may not be able to justify efficiency-enhancing investments if competition from uncovered firms causes them to lose market share.

The art of leakage policy is to try to correct for the challenges that emerge when carbon prices are not globally harmonized, while, at the same time, not undermining the benefits that are expected from the carbon pricing in the first place.

Policy makers must address these issues in relation to two important and interrelated considerations:

- choosing which entities to provide assistance to; and
- determining the mechanism for providing assistance.

The discussion in the remainder of this section considers the first of these issues; section 5 considers the second.

The above discussion also helps to identify a difference between “efficient” and “inefficient” leakage. As noted above, carbon pricing is intended to allow less emissions-intensive firms gaining market share at the expense of more emissions-intensive firms. This can be thought of as a desirable, or efficient, outcome of the policy, even if these less emissions-intensive firms are located in different jurisdictions⁷. By contrast, inefficient carbon leakage relates to shifts in production and hence emissions that arise because of a differential in the stringency of carbon pricing policies (or equivalent regulations). This distinction is discussed in the following sections.

4.1. Breadth of Assistance

Policy makers face a series of choices in determining how broadly to provide assistance to protect against leakage. Three key choices are:

- whether to give assistance to electricity generators;
- whether to provide assistance to all entities that are not electricity generators, or whether to limit assistance to only a subset of these entities; and
- whether to provide assistance to all eligible entities on a uniform basis, or whether to provide “tiered” assistance that increases according to a firm or sector’s assessed exposure to carbon leakage.

The approaches to these questions adopted in a range of carbon pricing regimes are summarized in Table 3.

The decision over the breadth of coverage of the assistance provision involves a trade-off between political economy considerations and the desire to avoid economic distortions and save scarce fiscal resources. On the one hand, broad coverage may be required to generate sufficient acceptance for a carbon-pricing scheme, especially at its inception. On the other hand, and depending on the type of assistance provided, there is a risk that providing assistance will limit the incentives firms face to reduce emissions, hence undermining the rationale for introducing the carbon price in the first place. Assistance also requires (implicitly or explicitly) significant fiscal resources for which there will typically be many competing uses.

The combination of these choices will determine the overall generosity of the assistance provided, as well as the fiscal cost and the risk of distorting abatement efforts. All else being equal:

- limiting or avoiding assistance to electricity generators will reduce the cost of assistance and, where electricity generators are not materially exposed to international competition, this will not introduce a substantial risk of leakage;

⁷ Indeed, it can even be thought of as desirable if the firms in the other jurisdiction do not currently face as high a carbon price, although in this case the extent of market share shifting between the cleaner and dirtier production is likely to be greater than would be achieved under a global carbon price.

Table 3. The Breadth of Assistance Provided Depends in Particular on Whether Generators Are Included, and Whether Eligibility or Tiers of Assistance Are Applied in Other Sectors

<i>Scheme</i>	<i>Period</i>	<i>Treatment of generators</i>	<i>Treatment of non-generators</i>	<i>Is assistance tiered or uniform?</i>
EU	Phases I and II	Included	All entities given assistance	Determined by national allocation plans but generally offered to all entities on the same basis
Kazakhstan	Since commencement	Included	All entities given assistance	Uniform
All Chinese ETS pilots (Beijing; Chongqing; Guangdong; Hubei; Shanghai; Shenzhen; Tianjin)	Since commencement	Included	All entities given assistance	Uniform
Korea	Since commencement	Included	All entities given assistance	Uniform
South Africa	From commencement	Included	All entities given assistance	Tiered based on trade exposure and the level of process emissions
California	2013 to 2017	Assisted through a mechanism specific to the electricity generation sector	All entities given assistance	Uniform
EU	Phase III	Generally excluded	All entities given assistance	Two tiers: entities exposed to leakage receive greater assistance
California	2018 to 2020	Assisted through a mechanism specific to the electricity generation sector	All entities given assistance	Three tiers: high, medium, and low exposure to leakage
Australia	Commencement to repeal	Assisted through a one-off compensatory assistance package	Limited to activities that meet eligibility criteria	Two tiers: “highly” and “moderately” exposed to leakage
New Zealand	Since commencement	Excluded	Limited to activities that meet eligibility criteria	Two tiers: “highly” and “moderately” exposed to leakage

Source: Vivid Economics

- providing assistance to all entities that are not electricity generators will introduce a greater fiscal cost and may risk reduced abatement effort compared with an approach where eligibility is limited; and
- providing assistance on a tiered basis will reduce the fiscal cost of assistance and may be appropriate to reflect the varying degree of exposure to leakage between sectors, although it will increase the complexity of the scheme.

To illustrate the interaction of these trade-offs, both the EU ETS Phase III and the (now repealed) Australian carbon-pricing mechanism have used a similar portion of their available emissions allowances, around 50 percent, as assistance measures to protect against the risk of carbon leakage, despite having quite different allocation approaches. The former does not provide safeguards against carbon leakage to electricity generators due to evidence of full cost pass-through, but focuses its efforts on the majority of manufacturing industries; the latter limited eligibility for non generators but provided an additional pool of assistance to generators as a transitional measure. As a demonstration on the point about political economy considerations, this transitional measure was not designed to protect against leakage since this was recognized as a low risk for this sector, but rather as a means of trying to smooth the transition to a new policy regime and to address energy security risks.

Often schemes have narrowed the breadth of sectors receiving assistance over time. For instance, the exclusion of the power sector in Phase III of the EU ETS reflected the recognition that providing assistance to entities that did not face international competition had led to windfall gains, where the cost of emissions were passed on to consumers irrespective of the value of assistance received. In addition, while nonpower sector entities continue to receive allocations even if they are not deemed to be exposed to carbon leakage, the extent of this assistance has been reduced.

4.2. Criteria to Determine Sectors at Risk

Where eligibility for assistance is limited or where the level of assistance is tiered, policy makers must make a judgment as to how to determine the relevant eligibility and assistance thresholds. Both approaches can be data-intensive, which may in part explain why early phases of carbon-pricing regimes often tend toward universal provision of free allowances. However, as noted above, this additional administrative complexity offers potentially significant advantages in the form of reduced fiscal costs and risk of distorting abatement efforts.

Policy makers have generally used two main indicators: carbon intensity and trade exposure, either in isolation or combination, to limit eligibility for assistance and to separate assistance categories into tiers. The logic of why these two factors are often used to determine exposure to leakage and the appropriate level of assistance is outlined below.

- Carbon intensity captures the *impact* that carbon pricing has on a particular firm or sector. It can be thought of, for these purposes, as the volume of emissions created per unit of output, revenue, value added, profit, or similar economic metric (the term *emissions intensity* can be used interchangeably). As carbon leakage is driven by carbon emission cost differentials between jurisdictions with and without carbon prices, the larger the impact of a given carbon price on sectors or firms, the greater the risk of leakage, all other things being equal.

- Trade exposure can be thought of as a proxy for the ability of a firm or sector to pass on costs without significant loss of market share, and hence their *exposure* to carbon prices. Trade, or the potential to trade, is what allows competition between producers in different jurisdictions. Therefore trade is critical to allow firms that face different carbon prices to compete. Where factors such as trade barriers or transport costs make trade unlikely to occur, covered firms are insulated from competition from uncovered competitors and the risk of carbon leakage should be small.

Table 4 shows the different factors that schemes have used to identify which sectors might be exposed to the risk of leakage. Consideration can also be given to the weighting of these factors and whether there is any feedback or relationship between criteria over time.

Table 4. Different Jurisdictions Apply Different Definitions and Thresholds to Assess Trade Exposure and Emissions Intensity

<i>Scheme (period)</i>	<i>Criteria</i>	<i>Definitions</i>	<i>Applied at firm or sectoral level?</i>
EU ETS Phase III	Cost increase >30%; or Trade intensity >30%; or Cost increase >5% and trade intensity >10% Qualitative assessment for borderline sectors	Cost increase: [(assumed carbon price (€30) × emissions) + (electricity consumption × carbon intensity of production × carbon price (€30))]/GVA Trade intensity: (imports + exports)/ (imports + production)	Sectoral
South Africa	Trade intensity >10% on a combined exports and imports measure; or Trade intensity >5% on an exports-only measure; or High process emissions	Trade intensity: (imports + exports)/output; or exports/output Process emissions eligibility definition is currently undefined	Firm
California (2018-2020)	Variously split into high, medium, and low exposure. This was based on a combination of tiers of emissions intensity and trade intensity. Emissions intensity tiers are: High: >10,000 tCO ₂ e per million dollars of revenue Medium: 1,000–9,999 tCO ₂ e per million dollars of revenue Low: 100–999 tCO ₂ e per million dollars of revenue Very low: <100 tCO ₂ e per million dollars of revenue Trade intensity tiers are: High: >19% Medium: 10–19% Low: <10%	Carbon intensity calculated as tonnes of CO ₂ e per million dollars of revenue metric Trade intensity: (imports + exports) / (shipments + imports)	Sector

Table continues next page

Table 4. Different Jurisdictions Apply Different Definitions and Thresholds to Assess Trade Exposure and Emissions Intensity (continued)

<i>Scheme (period)</i>	<i>Criteria</i>	<i>Definitions</i>	<i>Applied at firm or sectoral level?</i>
New Zealand	Highly exposed if carbon intensity > 1,600 tCO ₂ e per million New Zealand dollars of revenue and trade exposed Moderately exposed if carbon intensity >800 tCO ₂ e per million New Zealand dollars of revenue and trade exposed	Carbon intensity is calculated as tonnes of CO ₂ e per million dollars of revenue metric Trade exposure is qualitative and based on the existence of trans-oceanic trade in the good in question. Electricity is explicitly excluded	Sector
Australia	Highly exposed if trade exposed and one of the following: carbon intensity >2,000 tCO ₂ e per million Australian dollars of revenue, or >6,000 tCO ₂ e per million Australian dollars of GVA Moderately exposed if trade exposed and one of the following: carbon intensity >1,000 tCO ₂ e per million Australian dollars of revenue, or >3,000 tCO ₂ e per million Australian dollars of GVA Trade exposed >10%	Carbon intensity is calculated as tonnes of CO ₂ e per million dollars of revenue metric or, alternatively, tonnes of CO ₂ e per million dollars of GVA Trade exposure based on either a quantitative test: (imports + exports)/production; or a qualitative assessment	Sector

Source: Vivid Economics

Note: GVA denotes gross value added

However, while these criteria are broadly recognized as being important in determining sectors exposed to carbon leakage, there are a number of important considerations.

- **First, in the academic literature a number of authors have argued that trade intensity, while relevant, is not a standalone driver of carbon leakage and only has an effect only when a sector or firm is also carbon-intensive.** One study finds that while carbon intensity is a strong indicator of leakage risk, trade exposure is not (Martin, Muûls, de Preux, & Wagner, 2014). Another argues that trade intensity provides no indication of the competitive dynamics of domestic firms against international competition, such as relative size and output, geographic scope and concentration, which would be necessary to evaluate market power inclusive of imports (Okereke & McDaniels, 2012). The suggestion that it is only the combination of impact (cost increase) and exposure (trade intensity) that is important in determining leakage risk is relevant to a number of country examples. For example, the South African carbon tax and Phase III of the EU ETS both, in differing ways, offer support to entities that are deemed to be trade-exposed, even if they are not carbon-intensive⁸.

⁸ By definition, the resources expended on providing leakage prevention to any one sector that is not carbon-intensive will be small, but the overall impact may still be significant if a sufficient number of sectors are protected.

- **Second, when considering carbon intensity, it is important to take into account the carbon emission costs passed through from the supplying sectors, particularly electricity, as well as the direct carbon emission costs incurred in production.** As noted earlier, carbon emission costs can affect production and investment decisions both through direct costs from a firm's own emissions and from indirect carbon emission costs, i.e. the increased input costs resulting from carbon pricing. However, estimating the effect of indirect carbon emission costs on a firm is more complicated than for direct emission costs as ideally the rate of cost pass-through from the supplying sector needs to be taken into account. This can be particularly challenging in the power sector, where it is most important, as the change in prices will depend on the structure of the electricity market: in some structures, it is possible that the impact of carbon prices on electricity prices could vary by time of day or season. Nevertheless, indirect carbon emission costs can be substantial for some industries, even allowing for incomplete pass-through. For example, a survey-based study estimated that the indirect costs for primary aluminum producers during Phase II of the EU ETS amounted to more than 3.5 percent of total production costs (Centre for European Policy Studies 2013).
- **Third, while energy cost shares can be used as a proxy for carbon intensity, they need to be used with caution as they can be quite imprecise.** Some schemes have suggested that carbon intensity can be approximated by examining energy intensity. This, for instance, was one of the options for assessing leakage discussed in the Waxman Markey bill that failed to pass through the US Congress in 2009. This approach can be attractive, especially as energy consumption data may be easier to obtain than emissions data. However, while fuel combustion on site and indirect emissions associated with electricity use will be broadly related to energy cost share, the price and emissions intensity of different fuels vary significantly, and the emissions intensity of electricity can vary greatly by location. Accordingly, energy cost share must be recognized as a highly simplified proxy for carbon intensity.

A further consideration is whether emissions intensity and/or trade exposure is assessed at the firm or sector level. In general, assessments have been made at the sector level to avoid rewarding firms that are more emissions-intensive than their competitors, and to avoid firms distorting sales patterns in order to satisfy trade exposure tests. It can also be more data-intensive to make assessments at the firm level, increasing administrative complexity. However, a firm-level approach could potentially limit eligibility for assistance, or higher tiers of assistance, thereby reducing the fiscal costs.

In addition to carbon and trade intensity, theoretical literature and historical experience suggest at least five other indicators of relevance:

1. Price sensitivity of consumers.
2. Competition within an industrial sector.
3. Availability and cost of abatement options.
4. Carbon pricing (implicit and explicit) among competitors.
5. The carbon intensity of production in other jurisdictions.

- 1. If consumers are highly price-sensitive, covered firms will be more likely to lose market share to uncovered competitors.** A general pattern holds that the more price-sensitive consumers are (i.e. the more elastic the demand curve), the lower the expected rate of pass-through⁹. In turn, the lower rates of cost pass-through generally imply high rates of output leakage, and vice versa. As this relationship is quite strong—and given that output and carbon leakage are strongly related—the degree of customer price sensitivity may be a useful indicator of leakage exposure. However, in practical terms, estimating the shape and slope of a sector’s demand curves can be challenging (Wooders, Cosby, & Stephenson, 2009).

The nature of competition within a sector, capturing the dynamics of both covered and uncovered firms, will affect the exposure of covered firms to carbon leakage. Concentration ratios have been found to be influential in determining exposure to leakage. The capacity to pass through the carbon emission cost in product prices will depend in part on the competitive nature of the relevant market (Reinaud, 2008). In a similar vein, Ritz (2009) finds that output leakage depends on the number and market share of unregulated firms; he argues that tougher competition in a given industry would be expected to lead to higher leakage rates for a given level of carbon and trade intensity. Intuitively, we would expect industries with a larger number of firms competing for market share to have lower profit margins, and vice versa. Accordingly, sector profitability could be used as a proxy measure of the intensity of competition, although measures of this type can face practical challenges due to profit volatility and confounding effects of tax practices (Sato, Neuhoﬀ, Graichen, Schumacher, & Matthes, 2015). However, it is of note that in the qualitative assessment of carbon leakage risk used in Phase III of the EU ETS—for sectors that did not quite qualify for assistance under the quantitative assessment—sector profitability was taken into account.

- 2. Abatement potential and cost can change the expected impact of carbon emission costs, thereby influencing investment decisions and leakage.** If a firm is able to reduce emissions at low cost it will be able to cost effectively reduce the carbon emission cost it faces, thus also reducing the risk of leakage. Following this logic, a lack of abatement opportunities is sometimes presented as a reason to expect loss of market share and therefore preferential policy treatment (Okereke & McDaniels, 2012). Abatement availability will depend on the time dimension required to develop less intensive technologies, the existence of these cost-effective technologies, and the effectiveness and credibility of the carbon price signal. Again, this factor was used in the qualitative assessment of carbon leakage risk used in Phase III of the EU ETS. However, despite the linkage drawn in the political and policy debate on this issue, and the literature showing that flexible mechanisms like carbon prices are effective at uncovering cheap abatement opportunities (Stavins, 1998), no studies have firmly established an empirical relationship between abatement opportunities and leakage.

⁹ Strictly speaking, this depends on the shape of the demand curve. For instance, under a linear demand curve the rate of cost pass-through is invariant to the elasticity of demand. However, under other typical demand curve specifications, including isoelastic demand curves, the relationship between elasticity and cost pass-through holds.

- 3. The level of implicit and explicit carbon pricing among competitors would be expected to affect the rate of leakage.** As carbon leakage is driven by carbon price differentials, if competing countries introduce carbon pricing policies of equivalent stringency this should lessen the risk of leakage. However, while the economic logic of this idea is sound, there are at least two practical challenges. First, it can be complicated by leakage mitigation measures in other countries: if one jurisdiction has a carbon price with leakage mitigation measures and the other has a carbon price with no such measures, the potential for distortion could remain. Second, in the case of firms exporting goods to a trading partner, it will not only be the presence or absence of carbon pricing in the trading partner itself that matters, but also the presence or absence of carbon pricing in third countries where there are firms located that are also trying to sell into the same export market. The growth in jurisdictions introducing carbon pricing means that this is very likely to be an increasingly important policy issue in the future. Indeed, prior to the repeal of its carbon pricing mechanism, Australia intended to take this issue into account when considering its carbon leakage provisions.
- 4. The carbon intensity of competitor firms.** As discussed above, one of the mechanisms by which carbon pricing can reduce emissions is by encouraging market share shifts from high- to low-emissions firms. This, in principle, means that “efficient” shifts in output from high- to low-emissions firms may be of less concern to policy makers, even if the low-emissions firms are located in different jurisdictions. This might suggest less need to provide leakage protection in cases where the carbon intensity of uncovered firms is lower than that of covered firms. However, despite some policy focus on this issue (Bosch & Kuenen, 2009), it has not yet been used as a criterion for determining which sectors should or should not receive policy support. This is partly because of difficulties in tracking the jurisdictions where output might increase following the introduction or strengthening of a carbon price, and partly because of uncertainty and variation in the carbon intensity of production in other jurisdictions.

The challenges in considering these issues has led to a focus on adopting relatively simple approaches to date, but this may change in future. As the value of assistance for individual firms and sectors is often politically contentious, policy makers have, to date, used relatively simple approaches based on emissions intensity and trade exposure that can achieve a high degree of targeting without introducing excessive complexity. However, as the carbon pricing landscape changes, especially as more jurisdictions introduce carbon pricing and other schemes reach maturity, it is plausible that there will be further refinement of the process of identifying sectors at risk of carbon leakage.

5. Policy Responses to Carbon Leakage: How to Support Sectors at Risk

5.1. Integrated versus Complementary Measures

Policy makers have considered and/or adopted a range of policy instruments to reduce the risk of leakage when designing a carbon pricing regime. These instruments can be split into two main groups: measures that are integrated into design of a carbon pricing scheme, or “integrated measures,” such as free allowance allocation; and measures that are external to, and operate in parallel with, the carbon pricing scheme, typically known as “complementary measures.” These include cash transfers to offset some of the carbon emission cost firms face, direct support for emissions reduction projects, and energy efficiency measures.

Integrated measures have a range of advantages in addressing leakage compared with complementary measures, and have been the generally preferred approach to date. The establishment of a carbon pricing scheme is normally dependent on establishing leakage measures deemed to be satisfactory to a range of interest groups. Directly incorporating measures that protect against leakage in the carbon pricing legislative package transparently addresses leakage concerns and can help secure the necessary political support. In addition, most integrated approaches are designed so that the value of the assistance automatically changes with the carbon price. This provides an effective hedge for firms facing the carbon price, and also reduces fiscal risks for governments as the cost of assistance varies with the potential revenue from issuing allowances. By contrast, complementary measures tend to have a less immediate impact on addressing leakage and are more challenging to design in a way that flexes in value with the carbon price. Reflecting the weight of practical experience, this section primarily focuses on the advantages and disadvantages of various forms of integrated measures; these are discussed in sections 5.2 to 5.4. Complementary measures are addressed in section 5.5.

5.2. Different Forms of Integrated Measures

A range of integrated measures are either operating in practice and/or have been discussed at length in the relevant literature:

- free allowance allocations (which, as described further below, can be broken down into three main types: OBA, grandfathering, and FSB);
- administrative exemptions;
- rebates (either direct or through changes in other taxes); and
- border carbon adjustments (BCAs).

These are all mechanisms that, in principle, can be targeted at specific sectors. As section 4 illustrates, there is likely to be merit in increasing focus on leakage prevention measures to a defined subset of sectors, especially as a scheme matures. As such, this section focuses on mechanisms where this is possible. In addition, other measures can be integrated into the design of the carbon price scheme that can reduce leakage risk by reducing the cost impact faced by all firms affected by carbon pricing. Such measures can include designing the scheme so that prices rise slowly from a low base, or through allowing the use of offsets. While these measures may have other merits, they tend not to discriminate between sectors, and are therefore not considered further.

5.2.1. Free Allowance Allocations

The most common policy mechanism that policy makers have used to address leakage to date is through the provision of free allowances under cap and trade schemes¹⁰. Providing free allowances reduces the total carbon emission costs that firms face and so is expected to reduce the risk of leakage. Free allowances have also been provided to achieve policy objectives other than leakage prevention.

Free allowances can be allocated in many different ways but are easiest to analyze when considered through two questions:

- Does the number of free allowances received by a firm vary (quickly) as the output of that firm varies?
- Is the number of free allowances received by a firm linked to the actual emissions of individual firm?

Allocations can either vary quickly as firm output levels change or they can stay fixed in the short-to-medium term. At one extreme, allocations can increase or decrease in proportion to a firm's output from one year to the next. At the other extreme, allocations are determined according to the firm's output in a historical period and left unchanged for an extended period. In practice, most schemes either update allocations annually, as in California, New Zealand, Australia, and Kazakhstan, or after a period of three or more years, as in the first two phases of the EU ETS and most of the recent Chinese ETS pilots.

In addition, the amount of allowances a firm receives can either reflect its actual emissions or be linked to a predefined "benchmarked" emissions intensity. The former approach is normally implemented through providing allowances that are some proportion of the firm's total emissions. By contrast, a benchmarking approach severs the link between a firm's own emissions and the allowances it receives. Instead, under this approach, a sector-wide assessment of an "appropriate" emissions intensity is made for all firms in the sector, and firms receive allowances in some proportion to their output multiplied by this benchmark. Firms that have an emissions intensity lower than the benchmark are advantaged and receive (proportionally) more allowances than firms that have an emissions intensity higher than the benchmark.

Combining the two approaches for allocating on the basis of output and emissions intensity suggests four conceptually distinct approaches to assistance. These four approaches are set out in Table 5. However, as the approach in the top left corner represents a "virtual exemption"¹¹ that would be more easily implemented through an administrative exemption, this option is not considered further here; administrative exemptions are instead discussed in section 5.5.2. Therefore, three primary assistance approaches remain. In practice, as Table 5 also shows, most approaches fit comfortably within one of these three categories, even if there are a range of subtle differences between each application.

It should be noted that, in principle, it is possible to include more than one type of assistance measure within any scheme. Box 4 explores the examples of Korea and Australia.

¹⁰ Impacts that are economically similar to free allowances under a cap and trade scheme can be achieved by transferable tax exemptions under a carbon tax. For example, carbon tax equivalents to free allowance allocations have been described in Pezzey (1992) and Pezzey & Jotzo (2012).

¹¹ If a firm were allocated allowances on the basis of both its actual output and its actual emissions intensity, the volume of allowances granted would move in direct proportion to its carbon cost, and so the firm would effectively be exempted from some or all of the carbon cost.

Table 5. Free Allocation Approaches Can Be Distinguished by How Allocations Vary with Respect to a Firm’s Output and Its Emissions Intensity

		<i>Do allocations vary in proportion to a firm’s output?</i>	
		<i>Yes: allocations update with the firm’s own output on a regular basis</i>	<i>No: allocations are based on a firm’s historical output with occasional periodic updating</i>
Do allocations vary in proportion to a firm’s emissions intensity?	Yes: allocations are directly proportional to the firm’s own emissions intensity	<u>Virtual exemption</u> : This would effectively eliminate the carbon price	<u>Grandfathering</u> : allocations are directly based on a firm’s historical emissions and do not vary as output changes, except between phases
		<u>Examples</u> : none based on allocations	<u>Examples</u> : EU ETS Phases I and II; Korea (all but three sectors); Kazakhstan Phases I and II; Beijing; Chongqing; Guangdong; Hubei; Tianjin
	No: allocations are benchmarked to an independent measure of emissions intensity	<u>Output-based allocation (OBA)</u> : Allocations are proportional to sector-wide benchmarks and a firm’s current output levels	<u>Fixed sector benchmark (FSB) allocation</u> : allocations are proportional to sector-wide benchmarks and firm-specific historical activity levels. Adjustments for changes in output only between phases
		<u>Examples</u> : California; New Zealand; Australia; Korea (three sectors); Shenzhen	<u>Examples</u> : EU ETS Phase III

Note: Some schemes use grandfathering for the majority of their allocations but adopt benchmarking approaches for new entrants or capacity expansions. These schemes are categorized as grandfathering for simplicity. The Shanghai ETS pilot involves a hybrid approach combining some elements of grandfathering and benchmarking, and so is not included in this typology.

Source: Vivid Economics

Box 4. Some Countries Provide Different Types of Free Allowance Allocation for Different Sectors

In the case of Korea, the intention is to aim for 100 percent of free allowance provision during the first phase of the scheme. However, the dynamics associated with the provision of free allowances differ across sectors. For the bulk of sectors, the scheme designers have adopted a grandfathering approach to free allowance allocation. However, they have opted for an OBA in the clinker, refineries and aviation sectors. This reflects the perceived relative ease of creating benchmarks in these three sectors. Policy makers have expressed a desire to shift increasingly toward the use of benchmarks in future phases of this scheme, although there is also concern about the complexity of creating a benchmark in cases where one plant produces a range of different product types.

In the case of Australia’s ETS, prior to its repeal, EITE sectors received assistance using an OBA approach with benchmarks. However, in addition, a one-off non updating allocation of allowances was provided to electricity generators. The allocations were not based directly on historical emissions but were similar in principle and intent to a pure grandfathering regime. The difference in approach in the nature of the assistance provided to these sectors had different policy rationales: with EITE sectors, there was a desire to protect against leakage; for generators, the intention was to smooth the transition to a new policy regime and address any risk to energy security. This is reflected in the different economic incentives created by alternative allocation approaches, as described further below.

5.2.2. Partial or Full Exemptions

Most carbon pricing regimes exempt some sectors or emitters through not defining the carbon price as applying to them, or by setting much reduced rates. Sometimes these exemptions are driven by practical difficulties in coverage or by broader political concerns about the sensitivity of imposing a cost on these sectors. This is often the case, for example, for small emitters, transport emissions, land use, land use change and forestry emissions, waste, and agriculture emissions. However, sometimes these are also justified on the basis of concerns about leakage. Some prominent examples are provided in Box 5.

5.2.3. Rebates

Sometimes policymakers aim to reduce the leakage risks associated with carbon prices by reducing other taxes paid by industry, or providing other subsidies to industry, often by an equivalent amount. This is an approach most commonly adopted in countries pursuing a carbon tax regime. The intention is to discourage carbon emissions while not increasing the overall tax liability faced by industrial firms. Box 6 provides a number of examples.

Box 5. Exemptions to Address Leakage Have Been Applied (or Are Planned to Be Applied) in a Number of Carbon Taxes

A prominent example of the proposed use of administrative exemptions to address leakage is under the proposed South African carbon tax. While all entities under this regime are expected to receive a basic 60 percent exemption irrespective of their exposure to leakage, exemption rates can be increased by up to 10 percent for firms that have high trade exposure (measured using the approach discussed in section 4.2) plus a further 10 percent for organizations that have a high proportion of process emissions (considered difficult to reduce). Firms will also be entitled to use offsets for up to 5–10 percent of their emissions liability. It is expected that, over time, these exemptions will be gradually withdrawn. Policy makers anticipate that a withdrawal of exemptions may be an easier way to increase the marginal tax rate faced by firms than a straightforward increase in the nominal rate.

A number of European countries have also provided for exemption from national CO₂ and energy taxes to address competitiveness concerns of heavy industry (Institute for European Environmental Policy, 2013):

- Under **Denmark's** CO₂ tax, a refund of 75 percent of the CO₂ tax paid is provided for energy used for heavy energy-intensive process purposes. “Heavy processes” are defined in law. Sectors are included if a CO₂ tax rate of €6.7 on the energy consumption of a particular process would result in a tax that exceeds 3 percent of the value added or 1 percent of the turnover.
- In **Finland**, where the CO₂ and energy taxes paid by a company for electricity, coal, natural gas, and other products exceed 0.5 percent of the company's value added during the accounting period, the company is entitled to apply for a refund of 85 percent of the amount of the excise duties paid for the products or the excise duties contained in their acquisition price. Only the part exceeding €50,000 of the calculated tax refund is repaid.
- In **Germany**, a relatively complicated system of reduced tax rates applies to a range of manufacturing sectors. However, notably, defined energy-intensive processes—including electrolysis and chemical reduction processes, the production of glass and ceramic products, and metal production and processing—benefit from a full exemption from all energy taxes, including the electricity tax.

Box 6. Carbon and Energy Taxes Can Be Introduced in Conjunction with Reductions in Other Taxes or Other Forms of Rebate

- In the **UK**, the introduction of the Climate Change Levy—a tax on industrial consumption of different fossil fuels—was intended to offset a reduction in national insurance contributions for those affected by the tax (Sumner, Bird, & Smith, 2009)^a.
- In **Denmark**, increases in energy taxes during the 1990s were accompanied by a reduction in the required employers’ contributions to the additional labor market pension fund, as well as a reduction in employers’ national insurance contributions (Institute for European Environmental Policy, 2013).
- **Sweden**: Although not related to carbon emissions, the Swedish tax on NOx emissions provides an interesting example. In this case, Sweden originally set a tax rate of 40 SEK for every kilogram of NOx emitted from any stationary combustion plant producing at least 50 megawatt hours (MWh) of useful energy per year^b. However, it also committed to returning all of the revenues raised to participating plants, in proportion to their production of useful energy. The result was that only plants with high emissions per unit of energy were net payers of the tax (OECD, 2013c).

^a Mandatory contributions paid by employees and employers on earnings, and by employers on certain benefits-in-kind provided to employees. National insurance contributions were subsequently increased.

^b The coverage has subsequently been expanded to all plants producing more than 25MWh of useful energy.

These examples show that there is a wide diversity in the implementation of this approach. Options differ depending on the tax/subsidy base through which the revenues are recycled—for example, output in the case of the Swedish NOx tax, and employment in the case of the UK Climate Change Levy. It can also differ depending on whether the revenues from the carbon tax are first explicitly calculated and then the rebate provided (to guarantee revenue neutrality at the government level), or whether the offsetting tax/subsidy change is introduced simultaneously, based only on an estimate of the expected revenue effects of the different fiscal changes¹².

5.2.4. Border Carbon Adjustments

BCAs are an integrated measure that has some common features with free allowance allocations, but fundamentally different economic, environmental, and political effects. BCAs involve a carbon emission cost being imposed at the border on importers of carbon-intensive goods and/or a rebate being provided to exporters. In common with free allowance allocation approaches, the carbon emission cost imposed or rebated could be determined through benchmarking akin to free allowance allocations. Further similarity arises in that one possible design is for exporters to receive their rebate in the form of free allowance allocations. The fundamental difference between BCAs and standard free allowance approaches is the effective extension of the carbon pricing regime to entities outside the implementing jurisdiction. This in turn dramatically changes the economic, environmental, and political effects of such a regime.

¹² For example, NERL reports that the Climate Change Levy revenues raised in 2006–07 were far less than the estimated revenue loss associated with the cut in national insurance contributions (Sumner, Bird, & Smith, 2009).

Box 7. Aspects of the Californian Carbon Price Scheme Resemble a BCA

California imposes a carbon liability on “first deliverers of electricity,” which includes both in-state generators and electricity importers. Importers can incur an emissions obligation based either on the emissions associated with a specified source of electricity or on a default factor in the absence of a specified source. Despite the narrow sectoral focus, the effect of these provisions is broadly equivalent to that of a BCA as they impose carbon emission costs on emissions from all sources of electricity supply, both inside and outside the relevant jurisdiction, with the intention of minimizing competitive distortions between in-state generators and importers.

The state has also publicly discussed the possibility of developing a BCA for the cement sector and will hold public workshops on this topic in summer 2015.

BCAs have been widely modeled and discussed, but less frequently implemented by policy makers. Though not explicitly described as such, the Californian ETS applies a form of BCA in the electricity sector. This is described in more detail in Box 7 above. The EU also considered a scheme that bore some similarities to BCAs for civil aviation in that it that would have imposed carbon emission costs on flights originating or ending outside the EU, as well as on intra-EU flights. However, as is discussed later in Box 14, this plan is currently suspended. Outside of the climate context, the United States imposed a tax on imports whose production relied on ozone-depleting chemicals and provided a tax rebate to manufacturers or exports of the same products (Hoerner, 1998).

5.2.5. Summary

This discussion indicates that there are six distinct types of integrated measures, three of which involve free allowance allocations. These approaches are:

- free allowances allocated on a grandfathering basis, where allocations are proportional to an individual firm’s historical emissions and there is no rapid adjustment if firms change their output;
- OBA of free allowances, where allocations are based on product-specific benchmarks and changes in output lead to rapid changes in allowance allocations;
- FSB, where allocations of free allowances are based on product-specific benchmarks (as with OBA) but without rapid adjustment if there are future changes in output (as with grandfathering);
- rebates, either directly or through other taxes;
- administrative exemptions; and
- BCAs.

The pros and cons of these various options are discussed in more detail in section 5.3 below.

5.3. Pros and Cons of Different Options

The integrated measures discussed above will create different economic and environmental incentives, and face different administrative and political challenges. In some cases these effects will be inherent to their fundamental design, and in others specific to detailed elements of design and implementation. For this reason, the following section discusses each option by drawing on the specific implications of the

design of individual jurisdictions' policies where relevant, while highlighting the general points inherent to each option. The section discusses both the economic and the environmental implications of each major policy option, as well as some of the key administrative issues surrounding the implementation of each.

Each mechanism is assessed against the outcome that would be expected under a globally harmonized carbon price. This builds on the discussion at the start of section 4. In particular, the following questions are considered for each leakage prevention mechanism:

- Will it allow firms in a relevant market to compete on a level playing field, or will differences in carbon regimes distort competition?
- Will it allow prices of emissions-intensive goods and services to increase so as to promote demand-side abatement?
- Will firms have an incentive to reduce their emissions intensity?

5.3.1. Grandfathering

Grandfathering appears attractive as it should not influence firm behavior and abatement incentives, and because of its relative ease of implementation. Under a pure grandfathering scheme, firms would receive assistance directly related to their historical emissions, and the amount would remain independent of future output decisions or decisions to reduce their carbon intensity. This means that grandfathering continues to provide firms with a strong incentive to reduce their emissions intensity: such a reduction lowers the carbon cost liability faced by the firm but has no impact on the free allowances it receives. It can therefore sell the surplus allowances and use the profits to pay off its abatement investment. This feature, combined with the relative simplicity of working out how much assistance to provide each firm, has made it a popular method of providing assistance in the initial stages of many carbon pricing schemes. Prominent examples include the first two phases of the EU ETS, the first phase of the Korea ETS (for most sectors), and various Chinese ETS pilots.

However, the corollary of not influencing firm behavior is that pure grandfathering is likely to be ineffective at addressing leakage in exposed sectors. Providing assistance on a grandfathered basis does not affect the incentives that firms face under a carbon price. As a consequence, even if higher costs brought about the carbon price would lead to a reduction in firm output¹³, this would still happen even with the provision of free allowances. If this reduction in output is associated with an increase in output from uncovered firms then output leakage—and hence some degree of carbon leakage—is likely to occur. In turn, this means that grandfathering may not be the allocation method that minimizes the cost of meeting a given emissions reduction target in cases where carbon leakage risk is significant (see, for example, Fischer & Fox, 2004).

In part because of leakage concerns, no carbon price scheme has involved a pure grandfathering allocation approach for the specific purpose of addressing leakage. Of greatest importance is updating:

¹³ This reduction in output takes place because the free allowances have an opportunity cost: by keeping output elevated and surrendering the allowance to cover the additional emissions associated with this high level of output, firms lose the option to sell the allowance instead. If the additional profits from selling the allowance are higher than the additional profits associated with keeping output at an elevated level, it will be rational for the firm to cut back on production and sell the allowances.

rather than maintain assistance levels indefinitely, schemes tend to revisit allocation decisions periodically. This typically takes place every three years, including in the case of first phases of the EU ETS and the Korea ETS, as well as in the various Chinese pilot ETSs: Beijing, Chongqing, Guangdong, Hubei, and Tianjin¹⁴. In addition, and for a variety of reasons¹⁵, schemes have tended to implement closure rules. Whereas under pure grandfathering, firms would be entitled to retain assistance indefinitely, even if they closed down with closure rules, continued entitlement to free allowances is made contingent on maintaining a minimum level of production.

Updating of allocations (and closure rules) can help to reduce leakage when applied to exposed sectors.

Both these departures increase the incentive on firms to maintain output at higher levels than under pure grandfathering. Updating creates a link between current output—and therefore emissions—and future allocations. Firms will be conscious that reduced output and emissions in this phase of the scheme is likely to result in less assistance in the next phase of the scheme. This creates an incentive for continued production and reduces the risk of output—and hence carbon—leakage where sectors are exposed to international competition. However, the strength of this incentive will depend on how far into the future the update will take place and the expected level of that allocation. Similarly, closure rules encourage firms to stay in operation to receive an allocation.

These rules reduce the otherwise strong incentive that firms would have to undertake abatement under grandfathering approaches.

- Updating rules limits the incentive to abate through reducing both output and the carbon intensity of production. Firms may be concerned that they will receive less assistance in the subsequent phases of the scheme. This is likely to be addressed only if it is signalled at an early stage that subsequent allocations will not be based on grandfathering, as indeed has been the case in a number of schemes¹⁶.
- Closure rules make it more likely that plants will stay open, even if it is more efficient for them to close. Indeed, much of the academic literature examining the early phases of the EU ETS highlight the effect of closure rules on keeping inefficient power generators in operation (see, for example, Sijm, Neuhoff, & Chen, 2006; Schleich & Betz, 2005; and Grubb & Sato, 2009). However, while closure rules limit the incentive to reduce emissions through reducing output, they should not influence the incentive to reduce emissions through reducing the carbon intensity of production.

Grandfathering may preserve demand-side abatement incentives but also runs the risk of windfall profits in nonexposed sectors. If the reduction in domestic output brought about by a carbon price with grandfathered emissions does not lead to an increase in overseas production because the domestic

¹⁴ The Korean and Chinese ETS are structured in phases. It is plausible that the allocation approaches of each scheme will be revisited for future phases; this is the explicit policy of the Korean ETS. Future phases may or may not retain a grandfathering approach.

¹⁵ Often these reasons are not linked, or perceived to be linked, to leakage considerations, but are instead introduced to prevent windfall profits or have a “common-sense” justification.

¹⁶ The EU ETS announced very early in Phase II a move to a benchmarking-based approach in Phase III. The Republic of Korea has adopted a grandfathering approach for most sectors for 2015 to 2017, but has expressed a general intent to move toward benchmarking from 2018. Policy makers in Kazakhstan have also indicated a preference for a move toward benchmarking from 2016 (World Bank Group, 2014a).

firms operate in a market with limited international competition, it will result in a price increase instead. This might stimulate some demand-side abatement, and indeed this is often seen as one of the benefits of grandfathering approaches. However, it may also lead to firms earning “windfall profits” from free allowance allocations. This occurs when the value of allocations a firm receives exceeds the cost exposure it faces, once adjusted for its ability to pass through carbon emission costs. The issue of windfall profits was widely discussed in the context of the power sector in Phases I and II of the EU ETS (Sijm, Neuhoff, & Chen, 2006). On the one hand, the presence of windfall profits might be thought of as part of a market-led reaction to the introduction of carbon pricing and so can help to smooth its introduction. However, especially if such profits become pervasive and permanent, they can be politically damaging, especially as they occur at the expense of other potential uses of carbon pricing revenue.

Grandfathering may also be an attractive way to provide assistance for reasons other than (inefficient) leakage. As noted in Box 4, prior to its repeal, the Australian carbon pricing mechanism included a one-off, non-updating allocation of allowances to electricity generators. These allocations were not provided on this basis that generators were exposed to leakage; rather, they were intended to provide a one-off support to those affected by the scheme. In this context, the fact that the allocation had limited impact on leakage was not a problem, while the retention of strong incentives for abatement, further strengthened by the fact that it was a one-off transfer, was a clear advantage. Similar arguments would support the use of (one-off) grandfathering in schemes where the majority of leakage would be efficient—in other words, where the carbon intensity in the jurisdiction introducing the carbon price is higher than in other jurisdictions—but where there is a desire to provide support to the affected industry.

In summary, grandfathering regimes face difficult trade-offs in addressing both abatement and leakage objectives, and while potentially attractive in the short term, they are unlikely to be a sustainable approach to providing assistance in the medium term. The pure grandfathering approach is ineffective in addressing output and carbon leakage in genuinely exposed sectors and is rarely adopted in practice. However, introducing adjustments to improve their effectiveness at reducing leakage compromises their effectiveness in stimulating abatement, especially because firms expect future assistance levels to be based on current emissions. There may, however, be a strong role for grandfathered support, especially on a one-off basis, as a form of transitional assistance (summarized in Box 8).

Box 8. Pros and Cons of Grandfathering

- Grandfathering is relatively easy to implement as it is primarily based on historical emissions data.
- Demand-side abatement incentives may be preserved.
- Incentives to reduce emissions intensity are diluted when allocations are likely to be updated as firms expect any reductions in emissions intensity to result in lower allocations in the future.
- Some risk of windfall profits, although such profits may also help ease the process of introducing carbon pricing.
- Leakage prevention is relatively weak, relying on closure rules to maintain minimal levels of output, and on updating to indirectly incentivize firms to maintain output.

5.3.2. Fixed Sector Benchmarking

FSB combines two features:

- as with grandfathering, assistance levels do not vary quickly and smoothly as firms change their level of output and emissions; and
- in contrast to grandfathering, the level of assistance is determined by reference to a product or sector-level benchmark emissions intensity rather than by reference to the current or historical emissions (intensity) of each individual firm.

In broad terms this is the approach adopted in Phase III of the EU ETS. A series of benchmarks were created for different activities under the cap, and the free allowances received by firms/installations in the sector were set by multiplying the firms'/installations' historical output level by the benchmark (plus a further downward adjustment). However, once the level of free allowance was set, future changes in firm/installation output had limited impact on the allowances received by each firm/installation.

Crucially, by severing the link between the emissions intensity of the firm and the allowances the firm receives, benchmarking better preserves incentives for firms to improve their emissions intensity than grandfathering. As explained above, under a grandfathering approach with periodic updating, firms may be reluctant to reduce their emissions intensity as it will reduce the free allowances they are entitled to receive in the future. Such a challenge is largely eliminated by this approach: it is the industry-wide benchmark, rather than firm-specific emissions, that will determine the amount of free allowances received in the future.

From an economic perspective the stringency of a FSB benchmark will have a minimal effect on incentives to reduce emissions and is largely a distributional question. In principle, regardless of where the benchmark is set, firms should have the same marginal incentive to reduce their emissions intensity. It should be immaterial whether a firm is more or less efficient than implied by the benchmark: if firms that are more emissions-intensive than the benchmark reduce their emissions intensity they will face a reduced carbon emission cost net of allocations. If they are less emissions-intensive than the benchmark, a further reduction in their emissions intensity would result in an excess of allowances, which they could sell. This is illustrated with a simple worked example in Table 6 below. This would imply that the level of the benchmark in the short run should not affect efficiency incentives, but does determine the allocation of resources between shareholders and taxpayers, who forgo revenue from auctioning allowances.

In practice the stringency of the benchmark may have implications for incentives, if for behavioral reasons firms respond more to the additional costs incurred as a result of having to make up the shortfall on their assistance levels than to the prospect of extra profits from further outperformance against the benchmark. This would support a more stringent benchmark to retain a strong incentive for abatement. It would also explain why many stakeholders are particularly interested in the stringency and level of the benchmark. The only current scheme using an FSB approach—Phase III of the EU ETS—sets a benchmark equal to the carbon intensity of the average of the best 10 percent performers in each sector.

Table 6. Investments That Reduce Emissions Intensity Earn the Same Return under Two Different Benchmarks

Variable	Unit	Low benchmark		High benchmark	
		Before investment	After investment	Before investment	After investment
Firm emissions intensity	tCO ₂ e/unit of output	1.0	0.8	1.0	0.8
Historical output	Units of output	100			
Benchmark	Allowances/ unit of output	0.7		0.9	
Allocation	tCO ₂ e	70		90	
Output	Units of output	100			
Emissions	tCO ₂ e	100	80	100	80
Carbon liability (emissions less allocations)	tCO ₂ e	30	10	10	-10
Reduction in carbon liability from abatement investment	tCO ₂ e	20		20	

Source: Vivid Economics

The calculation of benchmarks is data-intensive and creates potential for lobbying around the allocation methodology, but is feasible. Complications arise through issues such as the existence of similar products with different production processes, and through multi-output production processes. However, the successful development of benchmarking approaches in the EU, as well as in relation to OBA in New Zealand, Australia, and California, as discussed below, indicates that these technical challenges can be overcome.

As with grandfathering, an FSB approach will be dependent on closure rules and updating to be very effective in addressing leakage. In principle, it would be possible to create an FSB scheme where the level of assistance was determined by reference to a benchmark level of emissions intensity multiplied by a historical output level, and for this assistance amount to remain unaltered, regardless of future output. However, this creates a similar dynamic to that of grandfathering; sectors genuinely exposed to international competition would still cut back on production and would lose market share to those not facing carbon prices. Accordingly, policy makers are likely to use closure rules and periodic updating to reduce the risk of leakage. The only practical example of FSB—Phase III of the EU ETS—has adopted a series of output thresholds to reduce leakage risk, although these have created further challenges, as explored in Box 9 below.

As with grandfathering, FSB approaches carry a risk of delivering windfall gains if applied to sectors that are not exposed to leakage. As the level of allocation is not dependent on current output levels, firms that are not exposed to international competition will have an incentive to reduce output and raise prices in response to a carbon emission cost. As with grandfathering, this increase in prices might stimulate some demand-side abatement but may also lead to firms earning windfall profits from free allowance allocations. While such windfall profits may help to smooth the process of introducing carbon pricing, they may also undermine public confidence in the scheme if they persist in the medium term.

Box 9. FSB in Phase III of the EU ETS

The FSB allocation approach under the EU ETS Phase III has a long period in which the output basis of the allocation is not updated. To improve its effectiveness in preventing leakage, policy has been designed to create a stronger link between allocations and output, which therefore facilitates stronger protection against leakage. Specifically, a historical output level is set, based either on output in 2005–08 or 2009–10 (Decision 2011/278/EU). Firms producing:

- less than 10 percent of their historical level in any one year receive no allocations in the subsequent year, effectively acting as a closure threshold;
- between 10 and 25 percent of the historical level activity receive allocations with a 25 percent weighting in the next year;
- between 25 and 50 percent of their historical level receive 50 percent of their full allocation in the next year; and
- more than 50 percent of their historical level receive their full allocation, including if their output exceeds their historical activity level.

In a comparison of production decisions in the EU cement sector between 2011 and 2012, one study indicates that firms might have increased their output levels in 2012 in order to ensure higher allowance allocations in 2013, the first year of Phase III (Branger, Ponssard, Sartor, & Sato, 2014). If it is considered that cement is at risk of carbon leakage, this suggests that the thresholds and allocations are having some effect in preserving output and hence addressing leakage.

However, the non-linearities built into this scheme provide a possibility for gaming: by setting production at a level just above a threshold, firms can receive allocations that exceed the carbon emission costs they face—i.e. at an output level of 51 percent of their historical activity level, firms would be entitled to receive 100 percent of their allocation (Branger, Ponssard, Sartor, & Sato, 2014).

Overall, FSB maintains incentives to improve emissions intensity better than grandfathering but its effectiveness in preventing leakage will depend on detailed design elements. Crucially, by severing the link between a firm’s own emissions (intensity) and the amount of current and future assistance it provides, it preserves incentives to improve carbon intensity better than grandfathering. However, without closure rules and updating, it is likely to face the same challenges as grandfathering in terms of preventing leakage. Some of the refinements to the basic model, such as those used in Phase III of the EU ETS, could help to address this problem by preserving stronger incentives for continued production (summarized in Box 10).

Box 10. Pros and Cons of FSB

- Demand-side abatement incentives may be preserved.
- Emissions intensity incentives are preserved by using firm-independent benchmarks.
- Establishing benchmarks creates a degree of administrative complexity and a risk of lobbying but experience suggests that these can be overcome.
- A risk of firms making windfall profits (although these may help smooth the introduction of a carbon pricing regime).
- Leakage prevention is relatively weak (although inclusion of closure rules or intermediate output thresholds can improve leakage prevention and periodic updating may also indirectly incentivize firms to maintain output).

5.3.3. Output-Based Allocations

OBA has two key properties:

- assistance is allocated according to a predetermined benchmark of emissions intensity; and
- when firms increase or decrease their output, the amount of assistance that they receive correspondingly rises or falls, according to the predefined benchmark level of intensity.

This model is similar to the FSB approach in that the initial allowance allocation is determined by an emissions benchmark (which could be calculated in exactly the same way as the FSB approach) multiplied by the firm output level. However, in contrast to the FSB approach, if there are subsequent changes in firm output, with just a small lag there is an adjustment in the allowances that the firm receives. Variants on this basic model are used for providing assistance in California, New Zealand, previously in Australia, some sectors in Korea, and in Shenzhen, China.

By using benchmarks OBA preserves incentives to reduce emissions intensity in a similar manner to FSB.

OBA uses benchmarks to provide the same allocation to producers of identical products, meaning that less carbon-intensive firms will gain a competitive advantage through lower carbon emission costs net of allocations. As with FSB, this property broadly preserves the desired pattern of competition—i.e. that emissions-efficient firms will have an advantage over emissions-inefficient firms. All else being equal, the efficiency-preserving properties of both benchmarking approaches, OBA and FSB, make them preferable to those without benchmarking.

In contrast to FSB and grandfathering, OBA targets leakage more strongly. Under OBA an extra unit of output will directly result in additional allocations. This can be contrasted with grandfathering and FSB schemes where extra output does not lead to additional assistance, other than where closure or other thresholds are applied. This works to maintain or increase output levels despite the pressure of competition from firms that do not face the carbon price. As such, it offers strong leakage protection. The volume preservation feature of OBA is even more attractive if there are opportunities to reduce the carbon intensity of production that firms will pursue only if they are confident that they will retain high levels of output in the future.

The level at which a benchmark is set will affect the level of protection against leakage. Because of the direct link between a firm's production and the amount of assistance it receives under this mechanism, the value at which the benchmark is set has a material impact on firms' incentives to produce. A stringent benchmark will offer weaker leakage protection as most firms would have an emissions intensity greater than the benchmark, and hence experience a net increase in costs from producing an extra unit of output. Conversely, a higher benchmark will better protect against leakage but could have the perverse outcome that even those firms with a relatively high emissions intensity (but lower than the benchmark) might increase production. In practice, benchmarking under OBA approaches has tended toward benchmarks that are between the average and best practice performance of industry in the jurisdiction in question. The benchmarks are often also changed over time to reflect one or both of the tightening of emissions targets or expected improvements in firm efficiency. The different approaches adopted in practice are summarized in Table 7.

Table 7. Benchmark Levels under OBA Are Generally Lower Than Average Industry Practice and Higher Than Best Practice in the Jurisdiction in Question

<i>Jurisdiction</i>	<i>Phase</i>	<i>Leakage exposure</i>	<i>Benchmark set by reference to</i>	<i>Adjustment over time</i>
New Zealand	Since commencement	High	90% of average emissions	None
New Zealand	Since commencement	Moderate	60% of average emissions	None
Australia	Prior to repeal	High	94.5% of average emissions	Annual decline of around 1.3% per year
Australia	Prior to repeal	Moderate	66% of average emissions	Annual decline of around 1.3% per year
California	2013–17	All	Higher of 100% of best practice (single observation) or 90% of average emissions	Annual decline of around 2% per year
California	From 2018	High	100% of the benchmark set for 2013–17, on the basis described above	Annual decline of around 2% per year
California	From 2018	Moderate	75% of the benchmark set for 2013–17, on the basis described above	Annual decline of around 2% per year
California	From 2018	Low	50% of the benchmark set for 2013–17, on the basis described above	Annual decline of around 2% per year

Source: Vivid Economics

OBA will limit price increases in sectors to which it is applied, dulling demand-side abatement but also protecting against windfall profits. OBA provides a strong incentive to maintain production levels. In turn, higher levels of output mean that end-user prices are lower than they would be under alternative forms of allocation. In sectors exposed to leakage this may not be material as international competition would serve to limit price increases in any case. However, in sectors that are not strongly exposed to international competition, this can mean that OBA dents incentives for demand-side abatement. This can often be a relatively low-cost form of abatement (for example, improving energy efficiency as a result of higher energy prices) and hence means that the cost of meeting a given emission reduction target may be unnecessarily high. A positive effect of OBA is that the suppression of price increases will reduce the risk of windfall gains compared with grandfathering or FSB.

One concern with an OBA approach is that there may be challenges in reconciling free allowance allocations with the overall cap; this may render the domestic environmental outcome of a carbon pricing regime less certain. The concern is that if firms that produce more output receive more assistance, the overall level of assistance they are entitled to receive cannot be known when a particular phase of the scheme starts, and it may rise to potentially higher levels than the overall cap on emissions. In these cases, there are three broad options available for policy makers (some or all of which could be adopted simultaneously).

- First, a range of steps can be taken to ensure that OBA approaches do not result in free allocation amounts that exceed the domestic emissions cap. As outlined in Table 7, all OBA approaches

reduce the level of benchmarks over time, in part to ensure that allocations do not exceed any relevant domestic emissions limit. However, as discussed above, a more stringent benchmark will offer weaker leakage protection, especially if the rate of decline in the benchmark is quicker than carbon intensity improvements. Alternatively, caps could be placed on the overall allowances that can be allocated on an OBA basis, although if this cap was reached then the mechanism would begin to resemble the FSB approach discussed above. Finally, tightly targeting the sectors receiving allocations under an OBA can help to ensure that the level of allowance allocation is substantially below the level of any domestic emissions cap.

- Second, increases in allowances allocated under an OBA approach could be offset by a reduction in the number of allowances offered through auctioning. This will increase the importance firms and sectors attach to being considered at risk of carbon leakage, which may lead to greater difficulties in managing the process of determining which sectors should receive this classification. There are also limits to the efficacy of this approach if the overall cap continues to be respected. However, assuming that the allocations genuinely target leakage, they can also be seen to be preserving the intended environmental objective of the scheme by minimizing the risk that emissions reductions within the scheme will be offset by increases in other jurisdictions.
- Third, the emissions cap can be relaxed so that it accommodates all increases in the output in sectors considered to be at risk of carbon leakage. This will ensure that leakage prevention measures continue to be effective but will undermine the environmental certainty of the scheme. As environmental certainty is seen as one of the key attractions of a cap and trade scheme over a carbon tax, this may be an unattractive option. The additional allowances will also reduce the carbon price within the scheme, lowering the long-term incentive to invest in more ambitious abatement options.

OBA approach could also involve higher administrative costs than Benchmarking and FSB approaches, because output data must be regularly reported.

In summary, OBA is attractive where it is closely targeted at sectors genuinely at risk of carbon leakage, but it is particularly unattractive if applied too broadly. OBA can be more effective at tackling leakage than the other allowance-based allocation methods discussed above. However, it delivers this by providing a stronger incentive to maintain or increase production than the alternatives. This keeps production levels elevated, lowering prices from the levels they would reach without the measure and hence reducing opportunities for demand-side abatement. As such, it is an approach that is damaging to abatement incentives when applied to sectors that are not genuinely at risk of leakage. Without careful design, there is also a risk that the environmental integrity of the scheme may be compromised (summarized in Box 11).

Box 11. Pros and Cons of Output-Based Allocations

- Emissions intensity incentives are preserved by using benchmarks.
- Leakage prevention is likely to be strong due to the clear and explicit link between output and allocations, although this is dependent on the level at which benchmarks are set.

box continues next page

Box 11. Pros and Cons of Output-Based Allocations *(continued)*

- Demand-side abatement incentives are likely to be dulled if applied too broadly
- Risk environmental outcome is less certain depending on design features.
- Establishing benchmarks creates a degree of administrative complexity and a risk of lobbying, but experience suggests that these can be overcome.
- Higher administrative costs as output data must also be regularly reported.

5.3.4. Exemptions

Exemptions are likely to be effective in addressing leakage and are administratively easy to implement, but fundamentally undermine the abatement incentives of carbon pricing. By reducing the effective carbon price that firms face, the risk of carbon leakage is directly reduced. However, reducing the effective carbon price also means that abatement incentives are reduced in three important ways: firms have a reduced incentive to improve their emissions intensity; relatively carbon-intensive firms do not suffer a competitive disadvantage compared with firms with lower emissions intensities; and product prices of carbon-intensive goods will not rise in a way that stimulates demand-side abatement.

As noted above, most carbon pricing regimes exempt some sectors or firms; the primary example where leakage concerns are clearly relevant to an exemption is the proposed South African carbon tax. All entities under this regime receive a basic 60 percent exemption. Of more relevance to leakage, this regime makes a modest adjustment of exemption rates of up to 10 percent on the basis of trade exposure, and of up to 10 percent where a sector has a large portion of process emissions. The former provision directly addresses the trade driver of leakage, while the latter provision works on the logic that these emissions are harder to abate, which, as noted in section 4.2, is a potential driver of leakage. While these provisions may broadly target leakage, they do so at the cost of preserving abatement incentives. The proposal to adjust the core 60 percent leakage rate by up to 10 percentage points to reward more efficient producers may have some effect in retaining abatement incentives, but its effect on leakage is unclear.

In general, exemptions for the purposes of leakage prevention are most likely to be necessary when establishing a carbon pricing regime and should be accompanied by an explicit plan to phase them out. This thinking underpins the South African carbon tax; the current policy proposal is to reduce the basic exemption rate from 2020, therefore increasing the carbon pricing signal. As any phase-out occurs it may be that further changes are required to ensure that South Africa's leakage protection measures are effective and sufficient to address economic concerns about leakage and any consequential political concerns. Box 12 provides a summary of the pros and cons of exemptions.

Box 12. Pros and Cons of Exemptions

- Demand-side abatement incentives will be dulled.
- Incentives to improve emissions intensity will not be preserved.
- Leakage prevention is likely to be strong, but inefficient firms will be artificially protected from competition from both domestic and international firms with lower emissions.
- Administrative exemptions are straightforward to implement.

5.3.5. Rebates

The impact of reducing other tax rates on preventing leakage will depend very heavily on the specific design. As noted above, there are many different ways in which these schemes can be designed. The most important of these in the context of leakage prevention is the way in which revenues are subsequently recycled.

All tax rebate schemes will preserve an incentive for firms to reduce their emissions intensity. The attractiveness of addressing leakage through changes elsewhere in the fiscal system is that it will not dilute the impact of the carbon price on the incentive of firms to reduce their carbon intensity. If a particular abatement opportunity that will reduce the emissions intensity of the firm is attractive at the prevailing (and expected future) carbon price then it would be sensible for the firm to reduce its emissions in this way; it will reduce the liability that it faces from the carbon price while not affecting how much revenue it receives through any recycling mechanism. This will also mean that less emissions-intensive firms will tend to gain market share to the benefit of more emissions-intensive firms.

The impact on leakage will depend very much on the way in which revenues are subsequently recycled. Two examples help to illustrate options at either end of the spectrum.

- First, as with the Swedish NOx tax approach, revenues could be recycled in proportion to *future* output. This creates a strong incentive to sustain production levels. If the intensity of international competition means that this sustained production would otherwise have switched to a location without an equivalent carbon price, this means that leakage has been effectively prevented. However, if the same approach is applied in sectors that are not strongly exposed to international competition, the impact that carbon price might have had on increasing product prices will be reduced (as firms will be incentivized to maintain/increase production), and hence opportunities for demand-side abatement will be reduced. These advantages and disadvantages closely resemble an output-based allocation under an ETS.
- At the other end of the spectrum, firms could be compensated on a lump-sum basis in a way that is entirely unlinked to future production decisions, apart from, perhaps, exceeding some minimum production threshold. An approach similar to this has been suggested as a design option under the South African carbon tax whereby firms considered to be at risk of carbon leakage would be entitled to receive grants to help reduce their carbon intensity (University of Cape Town Energy Research Centre, 2013). Under this approach, recycling would provide no incentive to maintain output, and the advantages and disadvantages are broadly reversed compared with the situation above. Firms will cut back on production. If this is associated with increases in production in other countries with less stringent policies then the result will be carbon leakage, despite the leakage prevention mechanism. However, in other markets where overseas production would not increase, the higher prices resulting from the reduction in production will lead to additional demand-side abatement and a more cost-effective policy. This closely resembles the advantages and disadvantages of the FSB approach described above.

Other cases represent intermediate outcomes. For example, some rebate schemes have focused on reducing employer national insurance contributions. As employment costs are likely to have some

relationship with output levels, this approach is likely to provide a stronger incentive to sustain production than the lump-sum allocation approach, but a weaker incentive than in the case of the pure output-based approach. It may also support reductions in carbon intensity per unit of output if those reductions in carbon intensity can be achieved by capital–labor substitution. The pros and cons of rebates are summarized in Box 13.

Box 13. Pros and Cons of Rebates

- Strong incentives to reduce emissions intensity.
- Remaining features depend on how the rebate is designed:
 - if the rebate is linked to output then it will resemble OBA under an ETS: effective at preventing leakage, but providing strong incentives to keep production levels high;
 - if the rebate is in the form of a lump-sum transfer, there is less protection against leakage but more incentive for demand-side abatement.

5.3.6. Border Carbon Adjustments

BCAs aim to extend the reach of carbon pricing. They do this by requiring a carbon emission cost to be imposed at the border on importers of carbon-intensive goods, unless the country from which the goods are being imported already has an equivalent carbon pricing regime. This can be introduced either as a border tax or, under an ETS, by requiring importers to surrender allowances at the point at which the good is imported. In some variants, it is proposed that rebates on carbon prices are provided to those exporting carbon-intensive goods to countries where there is no equivalent carbon pricing regime.

In principle BCAs can successfully mimic economic and environmental outcomes under a widely harmonized carbon pricing regime, indicating its broad efficiency and effectiveness. By imposing a carbon emission cost on imports that would not otherwise be subject to such a cost, BCAs effectively increase the price of emissions-intensive goods. This has three key effects on abatement incentives. First, it promotes demand-side abatement. Second, it means that firms competing to supply the good do so on level terms, helping firms with a lower emissions intensity to outcompete relatively emissions-intensive firms. Third, all firms selling into the domestic market, both domestic and foreign, have an incentive to reduce their emissions intensity. In cases where the BCA regime also provides a rebate for those exporting carbon-intensive goods, there is no beneficial impact on demand-side incentives or on incentives to reduce emissions intensity, but a level playing field is maintained.

A further possible advantage of BCAs is that they may encourage the spread of carbon pricing as the introduction of domestic carbon pricing would allow revenues to be collected domestically. The strength of this argument in favor of BCAs will depend largely on the magnitude of the impact that they have on trade patterns and the likelihood that those introducing a BCA would be able to sustain the arrangement, potentially in the face of significant political pressure and threat of retaliatory trade measures. This will lead to an overall increase in mitigation only if the domestic carbon price introduced by other countries in response to the BCA is higher and/or has a broader coverage than the BCA.

Modeling of the potential effectiveness of BCAs generally suggests that they would be effective in reducing leakage. Branger & Quirion (2013) examine 25 studies and find 310 estimates of carbon leakage ratios across the various scenarios and models used. Their meta-regression analysis indicates that BCAs reduce leakage rates by around 6 percentage points on average, holding all other parameters constant. This rate is substantial given that leakage rates studied range only from –5 to 15 percent in the BCA scenarios, and 5 to 25 percent without the policy. The potential effectiveness of BCAs was also supported by analysis utilizing harmonized parameters across a variety of models through the Energy Modeling Forum; this analysis found that BCAs on average reduced leakage rates from 12 percent to 8 percent relative to a reference scenario with no BCAs or allocations (Böhringer, Balistreri, & Rutherford, 2012). Likewise, Hoerner (1998) suggests that the experience of the import tax adjustment for ozone-depleting substances in the United States “*establishes the importance of BTAs [Border Tax Adjustments] to achieving the benefits of environmental taxation.*”

However, the administrative difficulties associated with border adjustments may be substantial. Administratively, BCAs require rules to calculate the embodied emissions and country of origin of products to deal with the trade of embodied intermediate inputs. Accounting for components of a product with embodied emissions arising from different places can generate complexity. Difficult choices arise in respect of determining the carbon intensity to attribute to imports; arguments can be made in favor of rates based on an individual facility, firm, or country, or conversely a general product-level rate. The facility- or firm-level approaches increase abatement incentives for firms outside the carbon pricing scheme, but also create incentives to “shuffle” production between destinations to minimize the border impost. By contrast, a product-level rate may not appropriately discriminate between different producers, but recognizes the substitutability of equivalent products from different locations within a global market. Different practitioners and commentators have taken different views on the extent of these administrative challenges: some consider that they make BCA regimes very difficult to implement in a way that maintains their environmental integrity (Persson, 2010). Others argue that, while administratively challenging, the experience of the tax for ozone-depleting substances, for example, suggests that it can be made to work. A number of commentators have suggested that, given the potential challenges, BCAs may be easier to introduce in a select number of sectors with relatively homogeneous products, such as cement, at least in the first instance (Helm, Hepburn & Ruta, 2012).

An alternative approach that would avoid these administrative challenges would be to impose a blanket tariff on all goods imported from countries without a carbon price. This tariff would be unrelated to the carbon content of any particular traded good. As such, the focus would be less on using BCAs to try to remove competitive distortions between different producers, and more on encouraging countries to adopt domestic carbon pricing (Nordhaus, 2015).

A related idea is to apply a carbon price on the consumption of carbon intensive products that are trade exposed, whether produced domestically or imported—such as (clinker) cement, aluminum, steel or certain fertilizers (Neuhoff et al., 2015). This would avoid the risk of leakage while encouraging demand-side abatement opportunities for these products. The downside is that they are also untested, and to be trade-neutral they would have to have a flat rate that does not differentiate between more or less carbon intensive products. Hence, they would not provide an incentive to improve production efficiency.

The concern that BCAs will drive leakage “downstream” to producers of more elaborately transformed products is unlikely to be a significant concern in many cases. Generally, leakage concerns are focused on energy-intensive transformation processes such as smelting and refining, rather than downstream processes such as fabrication and casting. Because BCAs raise the price of carbon-intensive commodities, downstream users of the products will pay more for their inputs. They may then face competition from downstream producers outside of the carbon pricing regime who can purchase commodity inputs such as steel or aluminum without a carbon price incorporated. The political implication is that leakage risk moves downstream, typically to sectors with greater employment and therefore often with greater political influence. The administrative implication is that a greater range of more elaborately transformed products may need to be incorporated within the BCA, requiring additional baselines to be established and, because more sectors are covered, including those not necessarily directly responsible for significant emissions, additional compliance effort. However, concerns about leakage of more elaborately transformed products should be tempered by the fact that these products are of higher value and so any embedded carbon emission cost would tend to be low compared with its overall value.

Legal considerations will influence any design but, many commentators suggest, will not represent an insuperable barrier. A number of commentators contend that World Trade Organization (WTO) requirements are likely to impose legal constraints on policy design, but that these could potentially be overcome. For example, one route to demonstrating the legality of BCAs would be under Article XX of the General Agreement on Tariffs and Trade; this allows for exemptions to general provisions for “measures that are necessary to protect human, animal or plant life, or health” (Article XX, b), and for measures that are “related to the conservation of exhaustible natural resources and are made effective in conjunction with restrictions on domestic production or consumption” (Article XX,g). This has been interpreted as implying that BCAs will need to be able to demonstrate their effectiveness at reducing emissions, rather than addressing carbon leakage (Monjon & Quirion, 2011). In turn, this may make export rebates more difficult to justify than import tariffs. Ultimately, it will be possible to assess the legality of BCAs only through the introduction of a regime and any (potential) subsequent challenge.

The political challenges may be as great, or greater, than any legal constraints. The experience of the EU in seeking to establish a regime that bore some similar characteristics to a BCA in the civil aviation sector demonstrates that the political challenges of introducing BCAs may be as, or more, significant than the legal challenges (see Box 14). Experts interviewed as part of this study claimed that it is possible that BCAs will become more feasible as and when (if) a sufficient proportion of major emitters are committed to such a regime. Border adjustment measures appear more feasible when introduced by a coalition of partners who account for a significant share of world trade. The most feasible path to this outcome may be through individual action by a number of major emitters, which might then seek to harmonize their regimes through a common BCA imposed on countries outside the grouping.

In summary, BCAs perform strongly against both abatement and leakage objectives but may be politically and administratively challenging to implement. In principle they are likely to be an effective measure for preventing leakage but implementation challenges may limit their application to a relatively specific set of circumstances. The pros and cons of BCAs are summarized in Box 15.

Box 14. EU Attempts to Set a Price on Foreign Emissions in the Civil Aviation Sector Proved Challenging

The EU attempted to develop a policy that bears some similarity to a BCA for the civil aviation sector. In January 2012 it launched the Aviation EU Emissions Trading System (Aviation EU ETS) to govern emissions from both flights within the European Economic Area, or EEA (which covers the EU plus Norway, Iceland, and Liechtenstein) and flights on starting or ending in the EEA. All such flights would be liable to surrender allowances under the EU ETS, with airlines facing a fine of €100 per ton of CO₂ emitted when this did not occur. Persistent offenders faced the possibility of bans from EU airports.

The Aviation EU ETS faced strong opposition from both developed and emerging economies. Representatives from 20 countries opposed to the rules, including the United States, China, India, and Russia, met in February 2012 to discuss measures they would take if the EU pursued the Aviation EU ETS (International Centre for Trade and Sustainable Development, 2012). These included:

- banning their airlines from participating in the scheme, a move which Chinese authorities had already enacted;
- filing a formal complaint with the International Civil Aviation Organization (ICAO);
- imposing levies or charges on EU airlines as a countermeasure;
- stopping talks with EU carriers on new routes; and
- asking the WTO to rule on the legality of the move. Although the European Court of Justice had previously deemed the rules compatible with international law.

The inclusion of flights to and from non-EEA countries has been suspended. In October 2013, the ICAO Assembly agreed to develop a global market-based measure to address international aviation emissions. It is due to take a decision on the measure in 2016, and to implement it from 2020. In response, the EU has decided to limit the scope of the EU ETS to flights within Europe until the end of 2016 and will further review the scope of the Aviation EU ETS following, 2015 ICAO Assembly.

The EU's policy preference is for aviation emissions to be dealt with through a global scheme such as that being negotiated in the ICAO Assembly. However, some commentators have interpreted the reasons for the EU's change in policy to include concerns regarding WTO compliance; the impact on international trade if countervailing measures were taken and consequences for international relations; and the prospect of an international climate change agreement (Marcu, Leader & Roth, 2014).

Box 15. Pros and Cons of BCAs

- Demand-side abatement incentives will be maintained due to the carbon emission costs imposed on imported goods, allowing domestic firms to raise prices.
- Incentives to improve emissions intensity will be preserved and may also be extended to firms outside the direct scope of the policy.
- Leakage prevention is likely to be strong.
- Political, administrative, and possibly legal challenges may limit application (with political challenges diminishing when introduced by a coalition with significant market power).

5.3.7. Summary

Policy makers must weigh the specific advantages and disadvantages of each leakage prevention measure in the context of their particular circumstances. Policy makers will need to make trade-offs between competing objectives with factors such as administrative complexity, the breadth of sectors receiving assistance, the maturity of the scheme, and political considerations influencing the specific mechanism at any one point in time.

BCAs arguably perform most strongly on grounds of abatement incentives, but face political, administrative (and, possibly, legal) challenges. They are particularly appealing in that they simultaneously offer the potential to remove the competitive distortion associated with asymmetric carbon pricing, while also ensuring that the firms with the lowest carbon intensities are at a competitive advantage, and also ensuring that demand-side abatement incentives are maintained. However, their application to carbon regulation remains largely untested. They appear more likely to be feasible when introduced by a coalition of partners who account for a significant share of world trade.

At the other end of the spectrum, exemptions perform most weakly in terms of abatement incentives but will be the easiest to implement. They are likely to be appropriate only as an interim measure to ensure sufficient support for carbon pricing when a scheme is in its infancy.

Of the free allocation approaches, those that utilize benchmarking (either OBA or FSB) are generally preferable to providing free allowances on a grandfathered basis. The attraction of both approaches is that they sever the link, which exists under grandfathering, between a firm's own historical emission levels and its free allowance allocation. Unless this link is broken there is a risk that firms will have little incentive to reduce their emissions intensity, as lower emissions in one period will be expected to lead to fewer free allowances in the future. While the creation of benchmarks may incur some additional administrative costs, the experience of the EU, Australia, New Zealand, and California—as well as the intention of South Africa (in a carbon tax context)—suggests that these challenges can be overcome. Grandfathering may be more appropriate in schemes in their earlier stages, where the need to tackle other administrative challenges may make benchmarking approaches appear too complex, or where there is a desire to provide one-off compensation for firms even if they are not at risk of leakage.

The trade-offs between the two benchmarking approaches (FSB and OBA) are more balanced. Output-based allocation may be more effective at preventing leakage but at the same time the greater incentive for continued/increased production it provides will result in lower product prices than an FSB approach, hence blunting demand-side abatement incentives. This will be particularly problematic if OBA is applied to sectors where the need for leakage protection is limited (and hence where prices would otherwise rise). Depending on the specific design, OBA may also not guarantee a specified environmental outcome.

Under a carbon tax regime, rebate mechanisms can be designed to emulate the properties seen under the free allowance benchmarking options. An output-based rebate, such as that used in the case of the Swedish NO_x tax, provides very similar properties to output-based allocation; alternatively, lump-sum rebates would resemble FSB approaches. Rebates through reductions in employer social security contributions represent an alternative between each extreme. Given these similarities to the free allowance alternatives, the trade-offs between each approach are also similar.

Table 8 provides a high level summary of the different integrated policy measures that can be used to reduce the risk of carbon leakage.

Table 8. Summary of Different Policy Responses

	<i>Grandfathering</i>	<i>FSB</i>	<i>OBA</i>	<i>Exemption</i>	<i>Rebates</i>	<i>BCA</i>
Leakage prevention	Weak, unless closure rules and updating included	Weak, unless closure rules and updating included	Strong	Strong	Depends on design	Strong
Incentives to improve emissions intensity	In principle strong, but diluted when updating included	Preserved	Preserved	Not preserved	Preserved	Preserved
Demand-side abatement incentives	Preserved	Preserved	Dulled, especially if applied to broadly	Removed	Depends on design	Preserved
Administrative complexity	Easy to implement	Some complexity in establishing benchmarks	Some complexity in establishing benchmarks and costs in collecting output data	Easy to implement	Some complexity	Very complex
Risk of windfall profits	Some risk	Some risk	No	No	No	No
Risk to environmental outcome	No	No	Some risk, depending on design	Yes, exempt emissions uncapped	Depends on Design	No
Political and legal challenges	No	No	No	No	No	Yes

5.4. Complementary Policies

Carbon pricing may not unlock all possible abatement options at least cost due to a range of market failures; these market failures create a case for complementary policies. Some important market failures include:

- **Knowledge spillovers:** private entities may not capture all of the benefit of their innovations, which may “spill over” to others. This reduces the expected return on innovation and means that the expected profits may not be sufficient to drive a socially optimal level of innovation. This observation holds generally, but is of particular importance to the development of low-emissions technologies, which are crucial to achieving low-cost long-run reductions in greenhouse gas emissions.
- **Access to finance:** firms may identify attractive abatement opportunities but financiers may not be aware of their benefits or may perceive their risks to be high. This imperfect and asymmetric

information may make it difficult for firms to finance cost-effective abatement investments. A lack of competition between capital providers may also restrict access to finance.

- **Information barriers:** firms (especially SMEs) and households may not have the time or expertise to identify and implement cost-effective abatement options such as energy efficiency investments. There may be a role for government intervention to overcome this barrier and drive adoption of equipment with a higher upfront cost but a lower lifecycle cost when energy savings are taken into account.
- **Network effects:** some technologies and practices become more attractive to an individual or firm as the general level of adoption increases. This may mean that private incentives to adopt are lower than ideal, and uptake is slowed. Government policy can play a role in overcoming these effects. An example in the context of low-emissions technologies might be electric vehicles: widespread adoption of electric vehicles would result in greater availability of charging stations, but adoption is unattractive until users can be confident that the charging infrastructure will be widely available.

Complementary policies may also be implemented for political reasons, such as directing support to strategic sectors, or to address existing distortions in the tax system.

Complementary policies could also be used to target assistance to sectors at risk of leakage. This might occur through grants, tax incentives, or financing assistance for emissions reduction projects for firms in leakage-exposed sectors, or for R&D on low-emissions technologies applicable in leakage-exposed sectors.

There are a few examples of sector-specific complementary measures that are directly aimed at addressing leakage. The clearest example of using cash transfers as a complementary measure to address carbon leakage is under Phase III of the EU ETS. Indirect carbon costs are associated with the costs of indirect emissions, i.e. emissions related to the production of consumed electricity. The ETS Directive allows Member States the opportunity to compensate for indirect carbon costs through national resources via state aid schemes. To ensure that such measures are undertaken in line with the EU's state aid rules, and applied within predefined boundaries across Member States, the Commission has published guidelines on state aid measures related to the ETS which, among other things, determine the eligibility of sectors for such compensation. Cash grants were also provided to address leakage concerns for coal mines with high fugitive emissions under the Australian carbon pricing mechanism through a policy known as the Coal Sector Jobs Package.

But in many cases addressing leakage was not necessarily the primary policy objective of the sector-specific complementary measures. For example, New Zealand provided support for R&D into emissions reduction opportunities in agriculture, while the Australian carbon pricing mechanism developed a range of complementary measures as discussed in Box 16. In these cases, the link between these measures and leakage prevention may not be strong: New Zealand also exempts agriculture from emissions liabilities, while the Australian measures may have been related more to managing broader political economy concerns related to the introduction of carbon pricing rather than to an expectation that they would have a material impact on leakage.

Box 16. Examples of Sector-Specific Complementary Measures under the Australian Carbon Pricing Mechanism

The now-repealed Australian carbon pricing mechanism was supported by a range of complementary measures for sectors that also received free allocations to address leakage under the *Jobs and Competitiveness Plan (JCP)* as well as for several sectors that in many cases were close to, but not quite, eligible for free allocations. These policies include:

- the *Steel Transformation and Advanced Assistance Plan*, which provided A\$300 million funding for R&D into low-emissions steel technologies, in addition to allocations to the steel sector under the JCP;
- the *Coal Mining Abatement Technology Support Package*, which provided A\$70 million in grants to support innovative emissions reduction projects by emissions-intensive underground coal mines, recognizing that coal mining was not eligible for JCP assistance but that some mines were particularly emissions-intensive;
- the *Clean Technology Investment Program*, which provided A\$800 million of grant funding for a range of emissions reduction projects in the manufacturing sector, particularly energy efficiency. A\$200 million was reserved for the firms in food and beverage processing and metals manufacturing; many firms in these areas were either recipients of assistance under the JCP or narrowly missed out on assistance.

As well as sector-specific complementary measures, broader-based complementary measures can be deployed; under some circumstances these can indirectly reduce leakage risk. A range of complementary policies can potentially unlock efficient abatement options that might otherwise be forgone due to the market failures identified above. These policies include: tax incentives, grants or financing assistance for low-emissions projects to overcome financing barriers resulting from asymmetric information; funding for low-emissions R&D to reflect the existence of positive knowledge spillovers; regulatory interventions to promote energy efficiency options that might be forgone due to information barriers; or direct support for abatement technologies where network effects hold back adoption. Where there are genuine market failures, these measures can reduce the overall cost of abatement. Furthermore, in many cases, these measures will work to reduce the prevailing carbon price under an ETS. In effect, the sectors benefiting from the complementary measures carry more of the specified emissions reduction burden, “taking pressure” off other sectors, potentially including those sectors exposed to leakage. However, there is a risk that this is achieved only by targeting abatement effort at relatively high-cost sources of abatement, losing one of the primary benefits of carbon pricing.

In summary, complementary measures are valuable in supporting broader emissions reduction objectives, as is reflected by their wide adoption across jurisdictions, but in most cases they have had only a marginal role in addressing leakage risk to date. Most jurisdictions with carbon prices also have some combination of support for emerging renewable technologies, energy efficiency measures, and low-emissions R&D. The nature and ambition of these policies vary across jurisdictions, but their broad adoption indicates the widespread acceptance of their value as part of the policy landscape in promoting deep decarbonization. These can help reduce carbon leakage risk in genuinely exposed sectors: either by

directly reducing the cost impact that particular sectors face, or indirectly, under a cap and trade scheme, by reducing the carbon price. Typically, the objective of these policies is unrelated to reducing carbon leakage risk, although there are a few cases where such measures have been directly focused on leakage concerns. Nonetheless, to date, there are no cases where countries have relied exclusively on these mechanisms to address leakage risk. This is likely to reflect the fact that these mechanisms are typically insufficiently comprehensive in terms of the sectors they cover or the extent of the cost increases they ameliorate. Furthermore, because they are not integrated within the broader carbon pricing framework, key stakeholders may not have sufficient confidence regarding their permanence.

6. Engaging Stakeholders on Carbon Leakage

As previously discussed, the confluence of potentially undesirable environmental, economic, and political consequences of carbon leakage means it is typically one of the most controversial and prominent aspects of the policy debate around the introduction of a carbon price. Carbon leakage is probably the single most common argument used to delay or derail the introduction of carbon prices around the world. This means that how this policy debate is managed can have a great influence on the successful design of policy to address these concerns and the successful introduction of a carbon price.

This section considers the role of stakeholder engagement in analyzing and addressing concerns about carbon leakage. Drawing from the experience to date, it discusses the modes of engagement that have been used, the options to frame the policy dialogue, and some of the lessons learned.

6.1. The Policy Debate and Role of Engagement

Carbon leakage has the potential to gain significant prominence in the overall policy debate around the introduction of carbon pricing. Arguments that the risk of leakage undermines the environmental outcomes, while at the same time leading to a decline in domestic production with potential job losses, can weaken support for the introduction of carbon pricing. In addition, measures to address carbon leakage normally involve the use of fiscal resources (explicit or implicit) that could be used for other purposes (to compensate households or other affected groups, or other general uses of revenue). This trade-off often requires a degree of political judgment providing the impetus for different interests to lobby decision makers.

Some incumbents will have an interest in resisting the introduction of a carbon price and/or to seek to be shielded from it through specific assistance measures and may use arguments around carbon leakage to support their interests. What they might share with the government and general public about their risk to carbon leakage is likely to be strategically selected.

Additionally, **concerns about carbon leakage are often at their most prominent when the introduction of a new carbon pricing policy is being considered.** That is, when industry and the general public do not have experience with carbon pricing to observe its real impact. This may result in inflated concerns about the potential for carbon leakage.

Effective stakeholder engagement can help to shape the public debate to make sure that it is not captured by certain interest groups and is grounded in evidence.

Effective stakeholder engagement will also be important for the more technical policy dialogue. Should the risk of leakage be assessed as significant for certain sectors, the effective design of leakage prevention measures would likely benefit from active cooperation from a range of stakeholders, for example to test and refine policy proposals, and provide important data and other technical inputs to the policy design process.

A successful stakeholder engagement process would therefore need to manage the more general public policy debate on the issue, as well as, the more technical dialogue. The modes of engagement and the

strategies' for framing those debates will need to be tailored to the level of debate. For example, while the technical dialogue may best be supported by detailed in-depth policy analysis, the more general public policy debate might be better served with a clear and simple-to-understand narrative. Furthermore, the policy debate will likely evolve over time and the best strategy for stakeholder engagement with it.

6.2. Modes of Engagement

Stakeholder engagement allows for relevant parties throughout a society to be appropriately consulted and informed on issues relating to carbon leakage and the design and implementation of prevention measures. Stakeholder engagement comes in many different forms, capturing a wide range of relevant stakeholders, and using any number of different modes of engagement.

Stakeholder engagement on carbon leakage can be difficult and involve some conflict but has significant benefits, such as: greater transparency in the policy debate; avoiding misinformation, resolving conflicts, and securing consensus and buy-in; ensuring policy reflects national priorities and circumstances allows for policy to draw on widespread expertise; enhancing trust between stakeholders and alleviate general skepticism; and helping raise and maintain public support. Stakeholder engagement is often a key driver of success in effective design and implementation of policy.

There is no single approach to stakeholder engagement which is suitable for every situation. Stakeholder engagement will depend on the context in which it happens. With such a wide variety of cultures, communities, business practices, government processes, and transparency mechanisms in place across the world, different jurisdictions have taken different approaches to stakeholder engagement. Typically the mode of engagement will be chosen to best suit the audience and purpose of the engagement. Some of the modes of engagement that have proved successful to date are discussed below.

Policy makers will often lay out a plan that defines the process for stakeholder engagement, setting out the objectives of the different engagements, whom to engage with, when to engage, what issues to engage on, and how to engage. Such a plan can provide a structured approach to stakeholder engagement and make the process more efficient and effective.

Several jurisdictions have used a formal consultation process to seek views and input on policy proposals. This involves the preparation and release of policy proposals on which stakeholders are invited to share their views. Typically the consultation occurs based on a concrete policy proposal or a set of options that have already been designed in some detail. Written discussion papers or policy papers are usually made available to stakeholders who are given a specified amount of time to submit their views on the proposal(s) in writing. These formal consultation processes can be open to the general public or targeted to the most relevant stakeholders. Box 17 explains the formal consultation process conducted in South Africa.

Some jurisdictions have used surveys and questionnaires to gain valuable information from stakeholders. Often the assessment of the risk and effective design of measures to address leakage will require in-depth knowledge and data on potentially affected firms. Surveys are one way to solicit this information. Surveys and questionnaires can also be used to gather views of different policy options and proposals. Box 18 illustrates how surveys and questionnaires have been used to inform the EU ETS.

Box 17. Formal Public Consultation on South Africa's Proposed Carbon Tax

The South African National Treasury conducted two formal public consultation processes in the development of the carbon tax policy. First in 2010 a discussion paper was released setting out three implementation options: taxes on measured GHG emissions, a fossil fuel input tax or taxes on energy outputs. Written submissions were invited from the public. Taking into account feedback received in those submissions, a broader consultation process, and further policy design, a carbon tax policy paper was released in 2013 outlining the tax's rationale and proposed design features. Again written submissions were invited from the public. Submitters were given a 3-month period to provide their views on the policy as proposed in the policy paper.

The stakeholder consultation process highlighted a number of issues that affect the carbon tax's design features. These included concerns about impacts on economic competitiveness. The currently proposed tax free thresholds were introduced in response to these views.

For additional information see: www.treasury.gov.za

Box 18. Questionnaire to Consult Stakeholders on EU ETS Post-2020 Carbon Leakage Provisions

In 2014 the European Commission conducted a 12-week stakeholder consultation on the post-2020 carbon leakage provision for the EU ETS using an electronic questionnaire. The results of the consultation fed into the policy development process on the 2030 climate and energy policy framework regarding the determination of post-2020 rules on free allocation and carbon leakage provisions in the EU ETS.

The consultation was open to all citizens and organizations. The stakeholder consultation process gathered a total of 440 responses from business and trade associations representing business interests, public authorities, civil society, and the general public.

The questionnaire consisted of 23 multiple choice questions alongside the possibility to provide written comments. [A sample of the questions].

The nature of the questionnaire allowed for stakeholder's views from the multiple choice questions to be quantified, which helped in analyzing views. The flexibility for stakeholders to add written comments to their submissions allowed for specific input to be captured during the consultation.

A summary analyzing the responses received during the consultation was prepared and made publicly available. Also to increase transparency organizations were asked to provide to the Commission and general public information about whom and what they represent in a transparency register.

For additional information see: http://ec.europa.eu/clima/consultations/articles/0023_en.htm

Consultation meetings with stakeholders are also typically an important part of engagement. Consultation meetings can take many different forms, including:

- one to many, for example a large meeting open to all interested stakeholders can be useful for communicating ideas and seeking input from a wide range of stakeholders (Box 19 illustrates how public meetings have been used in California);
- one to some, for example targeting a select group of representatives from industry, government, NGOs, or academia, where the group is smaller and potentially more interactive;
- one to one meetings with specific stakeholders that can be useful for addressing particular concerns or seeking specific input.

Representative committees can also be established to support the stakeholder consultation process.

These committees are often established with a specific mandate and would be engaged regularly throughout the policy development process. Participants in the committee would be chosen for their particular expertise or view point. Box 20 provides some examples of groups and committee's established in New Zealand as part of the policy development process.

Stakeholder engagement will also often include a media campaign that might use radio, television, newspapers, and social media to explain policy or address concerns as they arise. These forms of engagement are particularly relevant for managing the general public policy debate. Typically the issues of carbon leakage would be incorporated into a wider campaign around carbon pricing.

Finally a range of other modes of engagement, such as a web page with relevant information, frequently asked questions, webinars, phone calls, and letters, can also be used to engage and communicate with stakeholders.

Box 19. Public Meeting on Possible Border Carbon Adjustment for the Cement Sector

On February 5, 2014, the California Air Resources Board held a public workshop to discuss potential inclusion of cement importers in the California Cap-and-Trade Program in the second compliance period using a border carbon adjustment mechanism. The workshop was open to all interested persons.

The workshop commenced the public process to consider regulatory amendments that would include cement importers as an additional covered sector subject to the California Cap-and-Trade Regulation (Regulation) in the second compliance period using a border carbon adjustment mechanism, potentially in concert with free allocation. The meeting was used to discuss options and technical considerations for including cement importers as part of the Regulation.

Staff of the Air Resources Board made a presentation providing the background and definitions; setting out the concept of a border carbon adjustment and then the design considerations. Following the presentation participants engaged in open discussion on the issues. Written comments on the issues and options presented were also invited for a 2-week period following the workshop.

For additional information see: <http://www.arb.ca.gov/cc/capandtrade/meetings/meetings.htm>

Box 20. Expert Groups Established to Support the Development of the New Zealand Emissions Trading Scheme

A number of expert groups were formed to provide advice on designing, improving, and operating the New Zealand ETS.

Electricity Allocation Factor (EAF) Contact Group: The EAF is a component of the allocative baseline that is used to calculate the allocation received by eligible industries. The contact group was established to develop a recommendation of the EAF for the period 2013-17 for the responsible minister. The group consisted of representatives from significantly affected parties that are familiar with electricity market issues and the NZ ETS. This includes people from government agencies, emissions intensive and trade exposed firms, power companies, and specialist consultants.

Climate Change Leadership Forum: The Climate Change Leadership Forum had 33 members, including six government chief executives and private sector participants from the agriculture, electricity, forestry, and industrial sectors. Additionally members also covered the science, environmental, and local government sectors and there were three Maori representatives. The purpose of the Forum was to facilitate communication between the government and the broader community as policy decisions were taken on the proposed design of a NZ ETS. The Forum provided an opportunity for community and business leaders to air their differing views on emissions trading and wider climate change policy as well as an opportunity to provide advice to help shape the design features of the ETS.

Technical Advisory Groups: A number of sector specific technical advisory groups were also formed during the policy development process. These groups were made up of technical and policy experts from the industry, government, and the science system. They provided input and guidance on ETS design options and acted as the principal forum for engaging with sector specific experts.

For additional information see: <http://www.climatechange.govt.nz/emissions-trading-scheme/building/groups/>

6.3. Framing the Debate

An important aspect of engagement is how the introduction of a carbon price and any associated concerns about carbon leakage are framed. Different governments have taken different approaches for framing the debate. Some of these options are discussed in this section.

Experience has shown that it can be helpful if concerns about carbon leakage are framed within a comprehensive carbon price policy narrative. If the case for carbon pricing is not well understood or widely supported, then concerns about carbon leakage, even if unfounded, can be used more easily to delay or undermine the introduction of the carbon price.

A strong evidence base can also help to frame the debate and address misinformation. As previously discussed, economic modeling and other ex-ante analysis can help policy makers and other stakeholders to better understand the potential risk of carbon leakage. This can help counter unfounded claims about risks of carbon leakage and better target assistance to those sectors and firms generally at risk.

Testing specific claims about risk of carbon leakage with a range of stakeholders can also be helpful to more fully understand the real risks. For example, testing a firm or sector's claim that they can't pass on the cost to their consumers with downstream producers who might also seek assistance because they expect the full cost to be passed on to them but do not expect to be able to pass it on further.

A clear and easy to understand narrative about the objective of any leakage prevention measures can also help to frame the debate. There can be a tendency for vested interests to move the carbon leakage debate into a broader discussion on industrial competitiveness, rather than environmental effectiveness. This risks carbon pricing policy being seen as a substitute for industrial policy. Explaining the difference between shifts in economic activity that are efficient and intended from the introduction of the carbon price, and those that are inefficient and resulting from asymmetric carbon pricing policy, can help to target assistance. Ideally any prevention measures would keep incentives sharp for companies and investors to improve emissions performance. A clear narrative will also directly relate the risk of carbon leakage to the carbon pricing policies in other countries. This provides a clear rationale/expectation to reduce assistance over time as more countries implement policies that provide an explicit or implicit carbon price. Box 21 describes how such a narrative has been provided for the EU ETS.

Making explicit the trade-off between leakage prevention measures and other uses of the fiscal resources can help balance interests. For example, if the general public understands that there is a direct relationship between the assistance provided to firms to reduce the risk of leakage and the resources available for other uses, including to support households, it may help decision makers make more balanced decisions.

It might even be possible to package the introduction of a carbon price and associated leakage concerns into a much broader policy reform package. For example, concerns around carbon leakage may be more moderate if revenue raised from the carbon price is explicitly tied to other public policy outcomes that are widely supported and have prominence (Box 22 provides an example).

Box 21. Easy to Understand Narrative on Carbon Leakage and the EU ETS

The European Commission sets out a clear narrative on carbon leakage with a dedicated web page to the issue. The web page clearly describes the issue, sets out the policy, and provides relevant documentation, related studies, and some frequently asked questions.

For more information see: http://ec.europa.eu/clima/policies/ets/cap/leakage/index_en.htm

Box 22. Chile's Carbon Tax a Part of a Broader Tax Reform Package

In September 2014 Chile passed legislation for the implementation of a carbon tax. The new legislation was a part of a much broader set of reforms, including changes to other tax laws, improvements to health and education systems, measures to increase social mobility, and other new environmental protections.

If concerns about carbon leakage are strong and unwavering despite the evidence base, and likely to become a barrier to the introduction of a carbon price, then the debate could be managed with the phasing-in of carbon pricing. One option would be to start with a lower price that rises over time, as for example is proposed in South Africa. Another option could be to start with somewhat generous assistance for firms potentially at risk of carbon leakage which can be phased down and/or narrowed over time, as for example was the experience in the EU ETS. Concerns over carbon leakage could be placated with some experience with carbon pricing and policy better targeted with the benefit of ex-post analysis. Ideally the intention to review or adjust assistance over time would be made explicit at the time of introducing the carbon price to avoid creating any expectation for ongoing entitlement.

6.4. Lessons Learned on Stakeholder Engagement

Stakeholder engagement is likely to be a key determinant of success in managing carbon leakage concerns and designing any prevention measures. Several jurisdictions have successfully used a transparent policy development process that incorporates both formal and informal engagement with a wide range of stakeholders. Experience has shown that policy makers can expect to engage on these issues with industry, technology providers, banking and services, civil society, and the general public throughout the policy development process. A clear engagement strategy that takes into account the different interests of, and draws on expertise and information from, a wide range of stakeholders can help manage the engagement process and make it more efficient and effective.

Carbon leakage could be raised as part of the general public policy debate, as well as in the technical policy development process. These two streams of debate might not progress in step with each other. For example, it is possible that the strongest and most active opponents in the general public debate will still engage constructively in the technical dialogue. Different modes of engagement will likely be needed throughout the course of the policy development process. Modes are best chosen to suit the audience and objective of the engagement.

Experience has shown that with the introduction of a carbon price, incentives for lobbying can be high, with strong vested interests who may use arguments around carbon leakage to protect those interests.

A clear and sensible public policy framework can therefore help to manage the debate. A strong evidence base, that assesses the potential risk of carbon leakage, is also important in this regard.

Some political judgment will be required to formulate the most appropriate policy response to concerns around carbon leakage. Compromises and trade-offs may be needed to find a policy formulation that is politically acceptable. High-level political leadership and commitment may be needed to drive the agenda. General political acceptance of the carbon price should help to contain the debate on carbon leakage. Engaging broadly at the political level can support this, for example, by briefing politicians across government, in opposition, and at different levels of government. Similarly, a whole-of-government process that keeps relevant ministries engaged and informed can support the policy development process and help to effectively manage the debate. Box 23 provides a practical example of how this was achieved in the Republic of Korea.

Box 23. Korea's Presidential Committee in Green Growth

Given the relevance of the proposed emissions trading system to a range of different interests and across different ministries, the Presidential Committee on Green Growth was charged with leading the development of the Korean emission trading legislation. The committee was established in 2013 and was co-chaired by the prime minister and a private-sector representative, with members from different government ministries.

Public opinion and therefore political support can shift over time. As such, there can be a trade-off between engaging in a long policy development process to design the perfect policy and getting the policy agreed and implemented while there is political support and/or momentum. In any event, carbon pricing policy and, in particular, measures to address the risk of carbon leakage can be reviewed and improved over time.

The broader policy context is likely to influence the policy debate around the introduction of a carbon price and associated carbon leakage concerns. For example, the public's general confidence in the economy could influence opinions on the importance of carbon leakage risk and associated output and job losses. Similarly, general trends in electricity prices could influence opinions on how much assistance should be given to firms to address the risk of leakage relative to households to offset the further increase in electricity prices that might be expected from the carbon price. Likewise, concerns around carbon leakage may be more moderate if revenue raised from the carbon price is explicitly tied to other public policy outcomes that are widely supported and have prominence.

The carbon pricing policies of other countries, including their measures to address the risk of carbon leakage, will likely be raised as part of the policy debate. A good understanding of those policies can help to inform the policy analysis, as the risk of carbon leakage will be reduced as more countries take on equivalent policies. At the same time, providing clarity on what other countries are doing and what this implies for the effective carbon price competing firms face can help to address misinformation and manage the carbon leakage debate.

Appendix 1: Leakage Prevention Mechanisms in a Range of Carbon Pricing Schemes

This appendix details the practical elements of the leakage prevention mechanisms in a selected number of carbon pricing schemes. As appropriate, it addresses:

- whether assistance is provided to all sectors/firms or just a subset of firms/sectors considered to be at risk of carbon leakage;
- how the scheme distinguishes between sectors deemed to be at risk of carbon leakage and those that are not;
- the type of assistance provided to sectors considered to be at risk of carbon leakage; and
- if the scheme uses benchmarking, how that benchmark is determined.

It concludes with a general discussion on the relative importance attached to different rationales for addressing carbon leakage, different approaches to modeling leakage risk, and broader policy considerations.

The detail—and the selection of countries covered—is informed by responses to a questionnaire designed by Vivid Economics and shared with selected countries as determined by the PMR Secretariat.

Australia

Prior to its repeal, the Australian carbon pricing scheme provided assistance to activities considered “Emissions Intensive Trade Exposed” (EITE) on a tiered basis. The level of assistance for which an activity was eligible was determined by the level of exposure:

- “highly exposed” activities were those which were both trade-exposed and one of the following: carbon intensity greater than 2,000 tCO₂e per million Australian dollars of revenue, or greater than 6,000 tCO₂e per million Australian dollars of GVA;
- “moderately exposed” activities were those which were trade-exposed and one of the following: carbon intensity greater than 1,000 tCO₂e per million Australian dollars of revenue, or greater than 3,000 tCO₂e per million Australian dollars of GVA.

The test for trade exposure was based on either a quantitative test: $[(\text{imports} + \text{exports}) / \text{production}]$ which needed to exceed 10 percent for a product from an activity to be considered trade-exposed; or a qualitative assessment.

EITE activities in Australia received assistance through an OBA approach using benchmarks. Allocations were updated in line with the activity’s output on a regular basis. In addition, a one-off non-updating allocation of allowances was provided to electricity generators. These allocations were not based directly on historical emissions but were similar in principle and intent to a pure grandfathering regime. The difference in approach for these sectors reflected different policy rationales: with EITE sectors, there was

a desire to protect against leakage; for generators, the intention was to smooth the transition to a new policy regime.

The benchmark was determined using two years of emissions data and the assistance rates were set according to whether the activity was “highly” or “moderately” exposed. Two years of emissions data (2006–07 and 2007–08) were used to determine the average emissions intensity of each activity. Assistance rates were set at 94.5 percent and 66 percent of this benchmark for “highly” and “moderately” emissions-intensive activities, respectively. The assistance rates declined at a rate of 1.3 percent per year, which was the same decline rate as the default cap. This was to ensure that the EITE share of allocations did not grow excessively relative to the default cap, but did not hold if more ambitious caps were determined. In general, the benchmark was set on the basis of one product/one benchmark. However, there were some exceptions: for example, petroleum-refining benchmarking was administered on the basis of inputs rather than outputs as there were fewer inputs than outputs and the emissions relationship between inputs and outputs was stable.

California

In the first phase of the California scheme (2013–17), with the exception of the power sector, all firms were entitled to free allowances under an output-based allocation. The benchmark for each sector was set on the basis of the higher of 90 percent of average emissions or 100 percent of the best practice, with an annual decline in the benchmark of 2 percent. A separate scheme for power generators exists.

From 2018, California intends to maintain an output-based allocation scheme but split sectors into highly exposed, moderately exposed, or low exposure, or based on a combination of emission intensity and trade intensity metrics. The emissions intensity tiers are:

- High: >10,000 tCO₂e per million dollars of revenue;
- Medium: 1,000–9,999 tCO₂e per million dollars of revenue;
- Low: 100–999 tCO₂e per million dollars of revenue;
- Very low: <100 tCO₂e per million dollars of revenue.

The trade intensity tiers are:

- High: >19%;
- Medium: 10–19%;
- Low: <10%.

Trade intensity is measured as (imports + exports) / (shipments + imports).

Table 9 shows how these different tiers are to be combined to determine the overall assessed exposure to carbon leakage risk.

The level of free allowance allocation received by different sectors will depend on the sector’s classification. Those at high risk of carbon leakage will receive free allowance at 100 percent of the 2013–17 benchmark; those moderately exposed receive 75 percent of the 2013–17 benchmark; and those

Table 9. From 2018, the Californian Scheme Intends to Classify Sector Exposure According to a Combination of Carbon Intensity and Trade Exposure

	<i>High trade exposure</i>	<i>Medium trade intensity</i>	<i>Low trade intensity</i>
High carbon intensity	HIGH	HIGH	HIGH
Medium carbon intensity	HIGH	MEDIUM	MEDIUM
Low carbon intensity	MEDIUM	MEDIUM	LOW
Very low carbon intensity	LOW	LOW	LOW

Source: Californian Environmental Protection Agency

with low exposure receive 50 percent of the 2013–17 benchmark. The benchmark in all three categories will continue to decline by 2 percent per annum.

Chile

Chile’s carbon pricing scheme was focused on the power sector so carbon leakage concerns were not significant. There is no electrical interconnection between Chile and other countries and so the risk of leakage does not arise directly for electricity generation. In addition, energy users did not express concerns about carbon leakage or competitiveness effects. This could be due, in part, to the nature of pass-through from electricity generation to end-users: for large users the pass-through mechanism depends on long-term contracts, but is likely to be slow; while for smaller users the regulatory system also slows the rate of pass-through. Concerns about the effects of carbon pricing in the construction sector led to a policy decision to exclude industrial process emissions generally, and cement in particular.

EU

Under Phase III of the EU ETS, all entities other than electricity generators are given assistance, with those considered to be exposed to leakage receiving a higher proportion of free allowances. This represents a decline in the proportion of allowances provided for free compared with Phases I and II, during which allocation decisions were made at the Member State level. The general exclusion of the power sector in Phase III was in recognition of the fact that providing assistance to entities that did not face international competition had led to windfall gains, where the cost of emissions was passed on to consumers irrespective of the value of assistance received. In addition, under Phase III, while nonpower sector entities continue to receive allocations even if they are not deemed to be exposed to carbon leakage, the extent of this assistance has been reduced.

The EU determines whether a sector is at risk of carbon leakage through a combination of trade intensity and cost increase metrics. The quantitative criteria are satisfied if the sector:

- faces a cost increase of greater than 30 percent; or
- has a trade intensity greater than 30 percent; or
- faces a cost increase greater than 5 percent and has a trade intensity greater than 10 percent.

Cost increase is calculated as: $[(\text{assumed carbon price (€30)} \times \text{emissions}) + (\text{electricity consumption} \times \text{carbon intensity of electricity production (0.465tCO}_2\text{/MWh)} \times \text{carbon price (€30)})] / \text{GVA}$. Trade intensity

is calculated as: $[(\text{imports} + \text{exports}) / (\text{imports} + \text{production})]$. For borderline sectors, the European Commission carries out a qualitative assessment.

The EU ETS uses FSB to determine the level of assistance. The Commission established a series of benchmarks for different activities under which the cap with free allowances received by firms/installations in the sector was set by multiplying an installation's historical output level (either average output between 2005 and 2008 or average output between 2009 and 2010) by the benchmark, with a further cross-sectional adjustment factor. However, once the level of free allowance was set, future changes in installation output had limited impact on the allowances received by each installation. The benchmark was set equal to the carbon intensity of the average of the best¹⁷ 10 percent of performers in each sector. Sectors deemed to be at risk of carbon leakage receive 100 percent of the benchmark, while other sectors receive 80 percent of their benchmark in 2013, falling to 30 percent by 2020.

The regime allows for some link between output and allocations. In general terms, the FSB allocation approach under the EU ETS Phase III means that a change in installation output would have no impact on allocation amounts. However, there are exceptions if firms produce significantly less output than their historical output. Specifically, firms producing:

- less than 10 percent of their historical output in any one year receive no allocations in the subsequent year. This effectively acts as a closure threshold;
- between 10 and 25 percent of their historical output receive allocations with a 25 percent weighting in the next year;
- between 25 and 50 percent of their historical output receive 50 percent of their full allocation in the next year; and
- more than 50 percent of their historical output receive their full allocation, including if output exceeds their historical output level.

New Zealand

New Zealand provides assistance on a tiered basis to sectors at risk of carbon leakage. The level of assistance is determined by the level of exposure:

- “highly exposed” sectors are those where carbon intensity is greater than 1,600 tCO₂e per million New Zealand dollars of revenue and they are trade-exposed;
- “moderately exposed” sectors are those where carbon intensity is greater than 800 tCO₂e per million New Zealand dollars of revenue and they are trade-exposed.

Trade exposure is assessed qualitatively on the basis of the existence of transoceanic trade of the good in question. Generators are excluded from receiving assistance.

EITE sectors in New Zealand receive assistance using an OBA approach with benchmarks. Allocations are updated on a regular basis in line with the sector's output.

¹⁷ In other words, the least carbon- intensive.

The benchmark was determined using two years of emissions data and the assistance rates were set according to whether the sector was “highly” or “moderately” exposed. The period from which the benchmark was set was flexible due to the availability of data. In general, a three-year period set by calendar or financial years through 2006–8 was used for all sectors as allocation rates were being set in late 2009/early 2010. Assistance rates were set at 90 percent of average emissions for “highly” emissions-intensive activities, and 60 percent for “moderately” emissions-intensive activities.

South Africa

South Africa provides assistance on a tiered basis to all sectors. Assistance is provided in the form of tax exemption with greater levels of assistance provided for firms that are trade-exposed and/or that have high process emissions. A 60 percent exemption applies to all firms and there is a further maximum of 10 percent for trade-exposed firms and 10 percent for firms in sectors deemed to have process emissions. The 60 percent exemption rate can also be adjusted up to 5 percentage points if a firm has a lower than average carbon intensity within the sector. The 60 percent rate will be in place for the first five years of the tax to 2020 and will then be reviewed.

Sectors eligible for extra assistance are those which have:

- a trade intensity greater than 10 percent on a combined exports and imports measure; or
- a trade intensity greater than 5 percent on an exports-only measure.

Trade intensity is: $[(\text{imports} + \text{exports})/\text{output}]$ or $(\text{exports}/\text{output})$ as appropriate.

South Africa plans to reduce the basic exemption rate over time in order to increase the carbon pricing signal.

Republic of Korea

100 percent of allowances will be allocated for free in the first phase (2015–17) of the Korean ETS, although with different approaches in different sectors. For the bulk of sectors, the scheme designers have adopted a grandfathering approach to free allowance allocation. However, they have opted for OBA in the clinker, refineries, and aviation sectors. This reflects the perceived relative ease of creating benchmarks in these three sectors. These are based on average emissions in the base period 2011–13. Policy makers have also expressed a desire to shift increasingly toward the use of benchmarks in future phases of this scheme, although there is also concern about the complexity of this.

In subsequent phases, it is intended that a greater proportion of allowances will be auctioned, but sectors considered to be EITE will continue to receive 100 percent of allowances for free. To assess which sectors are EITE, the scheme uses a combination of trade exposure and production cost increase, according to the following criteria:

- if trade intensity is greater than 30 percent, irrespective of cost uplift;
- if the production cost increase is greater than 30 percent;
- if trade intensity is greater than 10 percent and production cost uplift is greater than 5 percent.

Trade intensity is: $[(\text{exports} + \text{imports}) / (\text{sales} + \text{imports})]$ while production cost increase is: $(\text{greenhouse gas emissions level} * \text{permit price}) / (\text{total value added})$. Most sectors qualify for assistance under the trade intensity threshold, with over 90 percent of sectors qualifying as EITE on this basis.

General Considerations

Among jurisdictions that have introduced carbon pricing schemes, the key rationale for introducing mechanisms to address carbon leakage was to prevent a movement of activity to unregulated countries.

Most respondents referred to these concerns and noted that they were particularly important if carbon pricing is introduced during an economic downturn. The second most cited reason for measures was to provide transitional assistance to industry to cope with new policy. Indeed, some stakeholders cited them as jointly important. The least cited rationale for introducing measures to counteract potential carbon leakage was to compensate industry for a change in the policy environment and to prevent an increase in global emissions.

Most countries used general equilibrium modeling to assess the risk of leakage and the effectiveness of mechanisms to prevent it, while few used partial equilibrium modeling. For some respondents, modeling was carried out in the context of policy development. Others indicated that macroeconomic modeling was not used for policy design; empirical data and analysis of stakeholder arguments were considered more important. This may be because macroeconomic modeling may not allow a very granular assessment within the most affected sectors or because of challenges in agreeing input assumptions. Sectoral modeling was carried out in some cases, but this was limited to one or two sectors in a few countries.

Appendix 2: Leakage and National Competitiveness

Carbon leakage is caused by competing firms facing different carbon costs and so is closely related to the issue of cost competitiveness. At the level of an individual firm or sector this issue is relatively easy to understand. Holding all other things constant, if firms in one jurisdiction face a new cost that their competitors do not, they will face either a loss of market share or a reduction in profit margins, or both. However, as discussed extensively in the main body of the text, the importance of carbon costs within the overall cost base of a firm or sector, and the importance of costs as a driver of firm or sector competitiveness, can differ significantly between sectors.

However, competitiveness at the national level is substantially different from that at the sector or firm level, and the implications of carbon pricing for national competitiveness are easily exaggerated. As cost competitiveness is not the sole or primary driver of competition in many markets, and because in a diversified economy competitiveness will be driven by a much broader range of factors than cost, it is important to draw a distinction between the broad concept of national competitiveness and the much narrower focus of the competitiveness implications of a regulatory cost change for a particular group of firms and sectors. Conflating national and sector- or firm-level competitiveness could lead to incorrect policy conclusions on the economic implications of leakage.

National competitiveness has proven an elusive concept to define: one focuses on a nation's relative productivity and associated trade outcomes, while the alternative sees absolute levels of productivity as driving overall economic success.

- **Under the relative productivity view, countries are seen as analogous to firms.** In this view, firms compete in a zero-sum game where a gain in market share means a direct loss for its competitors, and vice versa. A perspective of this kind places a country's productivity relative to other countries as paramount; it must increase its exports and reduce its imports so as to displace these competitors from the global market for goods and services. Trade balance is a critical indicator of economic success. Krugman gives a prominent example of the use of this view in political debate, quoting former US president Clinton's statement that each nation is "like a big corporation competing in the global marketplace" (Krugman, 1994).
- **The alternative view is that international trade is not a zero-sum game and absolute domestic productivity is of primary importance irrespective of what other nations do.** Krugman (1994) argues that, unlike corporations, nations are each other's export markets and sources of imports: if the European economy does well, its consumers will demand more US goods and sell better quality imports to US consumers at lower prices. Krugman argues that for large nations, such as the United States, it is *domestic productivity* that is critical, especially as only a small portion of its goods are exported. He further argues that the relationship between economic performance and trade balance is ambiguous, citing the example of Mexico, which ran large trade surpluses when its economy was performing poorly as it needed to service foreign debt, and then ran trade deficits when its economy recovered and foreign capital flows returned.

Box 24. International Organizations Incorporate Many Elements in Their Definition of Competitiveness

The World Economic Forum (2014) identifies 12 factors in three groupings that are important in determining a country's global competitiveness:

- basic requirements: these include the strength of institutions, infrastructure, macroeconomic environment, health, and primary education;
- efficiency enhancers: these include higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, and market size; and
- innovation and sophistication factors: these focus primarily on business innovation.

In practice, most modern conceptions of national competitiveness are broad and focus on domestic productivity. Laura D'Andrea Tyson, Chairman of the US Council of Economic Advisors, was an early mover to combine both perspectives; to her, the competitiveness of an economy is its "ability to produce goods and services that meet the test of international competition while [its] citizens enjoy a standard of living that is both rising and sustainable" (Tyson, 1992). The former element reflects something of the relative productivity view, but the latter is broadly consistent with Krugman's thesis. Other, more recent, definitions of national competitiveness can essentially be reduced to productivity and anything that supports it; examples are Aiginger (2006) and Porter (2003). Another approach is to focus on drivers of national competitiveness; this is the approach of the World Economic Forum detailed in Box 24. This example highlights a range of measures that are largely directed toward enhancing productivity, resulting in a conception of competitiveness that is difficult to distinguish from productivity.

A 2012 National Bureau of Economic Research (NBER) paper offers a potentially useful synergy of the two conceptions of productivity. The authors define "foundational competitiveness" as a measure of potential productivity, but separately define the concept of "global investment attractiveness" as the gap between a nation's potential productivity and its current factor costs (Delgado, Ketels, Porter, & Stern, 2012). This view captures some elements of the relative productivity conception of competitiveness in a more robust framework; one would expect a nation with factors of production that are cheap relative to its actual or potential output to attract investment activity.

While this suggests that national competitiveness is primarily determined by domestic productivity, the importance of cost competitiveness will differ across countries. Countries that fail to grow and diversify away from commodity production will tend to be more impacted by changes in costs, including changes in environmental compliance costs.

Even for emissions-intensive economies, national competitiveness concerns need not prevent adoption of carbon pricing; prudent leakage prevention measures and broader economic diversification may be a more long-term robust strategy. Carbon leakage can be addressed through targeted leakage prevention measures rather than by abandoning emissions reduction objectives. Addressing climate change implies global structural change in the production and consumption of emissions-intensive goods; countries and firms that fail to prepare for these changes may find that the basis of their comparative advantage in a world

without carbon pricing is not sustainable. Seeking to preserve the basis of today's cost competitiveness in the long run in the face of fundamental structural change may well prove a riskier strategy than one of gradual adaptation and diversification. Carbon pricing prepares a country for these longer-run changes, and leakage prevention measures can be an appropriate transitional measure to allow these changes to occur gradually. In the long run prosperity is protected by effectively diversifying away from emissions-intensive goods and services.

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