International Carbon Action Partnership

Carbon Leakage and Deep Decarbonization

Future-proofing Carbon Leakage Protection

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Summary for policymakers

To avoid the most severe social, economic, and environmental impacts of climate change, the parties to the Paris Agreement committed to keep global warming to well below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 degrees Celsius. To achieve this goal, policymakers will face new challenges in balancing efforts to transition to a competitive, low-carbon economy with short-term economic and social pressures that arise from increasing carbon prices in the face of differences in the stringency of domestic climate policy.

When it comes to carbon pricing and emissions trading, in particular in the absence of a global carbon market, differences in prices for emission allowances give rise to concerns about carbon leakage and a loss of competitiveness for domestic firms in jurisdictions with robust carbon pricing. This can result in shifting emissions and production abroad as domestic firms lose market share to foreign competitors that face fewer constraints on their emissions. Carbon leakage thereby presents both environmental concerns and potential economic, social, and political challenges. To date, all jurisdictions that have implemented an emissions trading system (ETS) have done so with provisions to protect against carbon leakage, in particular for emissions-intensive, trade exposed (EITE) industries. These EITE sectors are typically evaluated for vulnerability to carbon leakage using standardized criteria and given at least a portion of their required allowances free of charge. However, the future longevity of such an approach will be constrained by at least three factors:

1. **Declining allowance budgets in line with carbon neutrality (net-zero targets)**: as mitigation efforts scale up and caps decline, the quantity of allowances that can be allocated for free will also decline, constraining ongoing free allocation as the primary carbon leakage response in the long term. This will be particularly acute in systems where industrial emissions account for a sizeable share of the allowance cap.

2. **The impact of free allocation on investments, innovation, and downstream mitigation options**: as domestic emission targets align to carbon neutrality, it will be essential that carbon prices incentivize both the production and consumption of cleaner alternatives to emissions-intensive products and provide a credible framework for low carbon investments.

3. **A changing carbon pricing landscape**: as more jurisdictions pursue carbon pricing to achieve their climate targets it will become increasingly important to reassess leakage protections in light of carbon costs at play among major trading partners to ensure those provisions are sufficiently targeted based on actual leakage risk.

Against this backdrop, this paper considers the decarbonization challenge for basic industrial materials and develops a conceptual framework for assessing the compatibility of carbon leakage provisions in driving deep decarbonization as well as alternative approaches to measuring and addressing the risk of leakage. These industrial commodities, typically classified as EITE, face unique abatement challenges while accounting for a sizable portion of global emissions and increasing demand in the coming decades.

CARBON PRICING AND DEEP INDUSTRIAL DECARBONIZATION

While significant decarbonization of the electricity sector has begun, emission reductions from industrial sectors to date have been limited (Neuhoff et al., 2018; Le Quere et al., 2018; Marcu et al., 2019). This is concerning, particularly given the contrast between the abatement efforts required and the growing global demand for basic materials from industrial sectors (e.g. cement, iron and steel, aluminum, plastics) that is required for global economic and social development (IEA, 2019a). The production of basic materials accounted for around 22% of global CO_2 emissions in 2016 (Bataille, 2019), while demand is estimated to increase two-to fourfold over the course of this century (Material Economics, 2018).

Delivering emission reductions from these sectors faces three key challenges:

1. high energy demand for production processes with limited opportunities for electrification (indirect emissions);
2. greenhouse gases (GHGs) produced through chemical transformations during the production process (process emissions); and
3. GHGs emitted through decay or incineration of the material at the end of its life.

Because of these challenges, deep decarbonization of basic industrial materials will require measures on both the supply and demand sides, as illustrated in Table S.1 and discussed at length in chapter two of this report. To illustrate how critical both sides of this equation are, one recent study estimates that over 50 percent of the reduction challenge in the European Union (EU) can be achieved by reducing demand and consuming materials more efficiently (Material Economics, 2018).

Table S.1: Mitigation opportunities from the industrial sectors

Supply		Demand	
Fuel switching and production efficiency	**Innovations in the production process**	**Material substitution**	**Low carbon consumption**
• Low to medium heating through renewables • Replacing the fossil fuel feedstock with sustainably produced biomass • Increasing the efficiency of production	• Incremental improvements in existing technologies • New low carbon production processes • Carbon capture and storage • Negative emission technologies	• Increased recycling • Improved (intermediate) production process • Substituting low carbon alternatives for high carbon materials	• Higher end use of products • Improved product design

Source: based on Neuhoff et al., 2018; Material Economics, 2018; ETC, 2018.

Carbon pricing can push the mitigation levers highlighted in Table S.1 by making carbon-intensive inputs such as fossil fuels more expensive and providing an incentive to use them more efficiently. It can also spur innovation in production processes, encourage a shift towards low-carbon alternatives, and generate revenue for the development and deployment of mitigation technologies. However, putting a price on emissions can lead to higher costs that put domestic industrial producers at a competitive disadvantage and may shift emissions abroad. Leakage concerns therefore create a conundrum for carbon-pricing policies, requiring a balance between supporting long-term competitiveness in a low-carbon economy and shorter-term leakage concerns among emissions-intensive industries.

With this in mind, a framework was developed with criteria for evaluating leakage protection measures that are consistent with the deep decarbonization challenge: 1) **providing ongoing protection against carbon leakage**; 2) **compatibility with long-term transition**, including incentives for low-carbon production, low-carbon consumption, and developing new technologies/markets; and 3) **political durability**, including international acceptance and ease of implementation.

FREE ALLOCATION AS AN APPROACH TO LEAKAGE PROTECTION

Free allocation of various forms has helped mitigate the risk of carbon leakage. **Grandparenting**, **fixed baseline period benchmarking**, and **output-based allocation** (OBA) present different advantages and disadvantages when evaluated against our framework. The bulk of chapter three focuses on these different methods of allocation as they relate to leakage and abatement incentives. Going forward, systems of ongoing free allocation will face several challenges. While the carbon leakage risk criteria determine the sectors eligible for free allocation, the total volume of allowances available is ultimately determined by the allowance cap as well as any mandated auctioning share. As ETSs move to more ambitious cap-reduction paths over this decade and the next, the total number of allowances available for leakage protection will decline.

This tension is acute for systems where industrial emissions make up a significant share of the allowance budget. Systems with an economy wide cap, where industrial emissions are a small share of the allowance budget, are unlikely to face allowance shortages. However, given cap adjustment factors built into free allocation formulas, industrial producers will face increasing carbon costs if mitigation does not keep pace with declining volumes of free allocation.

The question then becomes whether those sectors at risk of carbon leakage can reduce their emissions in pace with declining free allocation budgets or whether, at some point, they will be exposed to increasing carbon costs and hence leakage risk. This challenge will be exacerbated in cases where the rules determining free allowance allocation threaten to distort deep decarbonization in these sectors. Addressing this concern will depend largely on where abatement opportunities lie for different industrial sectors and whether the allowance price, as mediated by the free allowance allocation approach, will trigger the necessary reductions. For sectors where abatement potential depends on innovation in product processes and demand response to higher product prices, there is substantial risk that they will not be equipped to reduce their emissions sufficiently under current policy settings.

ASSESSING CARBON LEAKAGE RISK

As the volume of allowances available for assistance becomes scarcer, it is essential that leakage risk assessment limits the number of sectors receiving allowances freely, hence reducing distortions and preserving the budget for those that need it most. This in turn requires reviewing current practices of assessing leakage risk, which is a major focus of chapter four. Currently, jurisdictions implementing unilateral carbon pricing have determined sectors eligible for protections from carbon leakage using two criteria. **Emissions intensity** is designed to capture the direct and indirect costs of carbon pricing and is measured by volume of emissions per unit of output, revenue, value-added, or profit. **Trade intensity** aims to capture the capacity of a regulated firm to pass through the costs of carbon pricing to customers without losing profit or market share to international competitors. It is often measured by the total volume of imports and exports of a product relative to imports and domestic production. EITE criteria have performed reasonably well in balancing tradeoffs between accuracy, administrative complexity, and consistency. However, across most systems this has resulted in a rather broad application of leakage protection provisions.

We have considered two responses to this challenge. The **first possible approach** is to adapt the carbon leakage risk criteria to better reflect actual risk and in doing so restrict the number of sectors that receive free allocation. However, based on a detailed assessment of the literature there is no clear choice of additional criteria that could be applied alongside existing EITE criteria to improve broad leakage assessment. Additional criteria come with caveats that would increase the complexity of leakage risk assessment, require significant additional data, and at times reduce the transparency of the approach. Furthermore, the provision of additional tests may also open alternative grounds for industry to inappropriately claim leakage risk, as they could choose from the most advantageous indicators.

Given these drawbacks, a **second possible approach** is adjusting the emissions and trade intensity thresholds for leakage protection. One model could be to increase the emissions-intensity and trade-intensity thresholds for qualification such that only those deemed to be of "high" risk qualify automatically. A more complex assessment with a wider range of criteria could then be applied to sectors at lower risk levels. The benefits of such an approach would need to be considered against the costs in terms of increased administrative complexity and reduced transparency. Another way to work with existing criteria would be to continue exclusively using EITE criteria but assigning different thresholds to different tiers (e.g. low, medium, and high) and giving each tier different levels of free allocation. California and Québec use such a tier-based approach, but both apply 100% assistance factors to all EITE entities at the benchmark level regardless of risk classification, though Québec will start differentiating assistance factors between 90-100% based on risk classification from 2021-2023 (assistance factors after that time have not yet been decided). In California, 100% assistance factors are required through 2030 by legislation. Total levels of free allocation in California and Québec will, however, continue to decline based on declining cap adjustment factors.

ALTERNATIVE APPROACHES TO ADDRESS CARBON LEAKAGE

Adjustments to the carbon leakage risk criteria may prolong free allocation budgets. However, ongoing free allocation may not be sufficient to support industries to decarbonize in pathways consistent with net zero. Two options that could replace or work alongside free allocation and are explored in chapter five include border carbon adjustments (BCAs) and consumption charges. Both would present new administrative and political challenges, as well as potential trade distortions, but both alternatives would likely unlock abatement opportunities.

BCAs apply tariffs or other measures to imported goods based on their embedded GHG emissions and/or rebates for domestic exports to markets that have not established comparable constraints on their emissions.

Their application would require balancing their effectiveness against leakage with World Trade Organization (WTO) compliance and administrative feasibility. An ETS jurisdiction considering BCA may consider engaging both with the WTO for greater clarity on the legal dimensions and with trading partners in bi- or -multilateral discussions on its plans before adoption. An analysis of the academic literature[1] and existing proposals suggests some guidelines or principles for jurisdictions considering a BCA.

- **A BCA that is narrow in scope – at least at the beginning – is likely more administratively and legally feasible**: Limiting an initial BCA to only the most vulnerable EITE sectors and only imports may help balancing the trade-offs in BCA design.
- **Different scopes of coverage may be appropriate for different sectors**: Leakage protections will vary sector by sector, depending on factors such as trade intensity. For some a BCA that only adjusts for overseas exports entering the implementing jurisdiction will capture much of the benefits. A BCA offering only rebates or exemptions for domestic production to overseas markets could be appropriate for some sectors in terms of leakage protection but remains relatively unexplored in the academic literature and would present significant drawbacks.
- **Covering both direct and indirect emissions would improve the scheme's effectiveness and may be administratively and legally feasible**: Including both direct and indirect emissions would likely improve the effectiveness of the BCA but would require multiple benchmarks and greater clarity from the WTO about legal ramifications if the implementing jurisdiction does not explicitly cover indirect emissions in its carbon-pricing system.
- **Benchmarks on direct emissions based on the implementing jurisdiction's production are likely more administratively and legally feasible**: Setting benchmarks of emissions intensity on which to base the adjustment for products included in the BCA will likely be necessary for legal reasons. Administrative and legal challenges will likely preclude setting benchmarks based on the average emissions intensity of each exporting country individually, as country-specific determinations are more likely to be considered discriminatory under WTO rules, or basing the adjustment on the actual verified emissions of each importer.
- **It may be advisable to avoid country-specific benchmarks on indirect emissions as well**: For similar reasons, benchmarks for indirect emissions that avoid country-specific determinations are likely easier administratively and legally. Region-specific benchmarks might help in these regards and offer a more effective response than a benchmark based on the implementing jurisdiction.
- **Phasing out free allocation is critical to unlocking the abatement incentives of BCA, but a transition period may be useful, especially to help secure industry support**: Continuing free allocation would mean removing the value of allowances from the border adjustment, but a transition approach may help alleviate concerns of the industries covered under the scheme. It may also mitigate concerns of trade partners by reducing the adjustments they would face at the beginning.

Enacting charges on the consumption of industrial materials while maintaining output-based allocation for producers may offer a promising alternative to BCA that would significantly improve abatement incentives on the demand side of the industrial value chain compared to free allocation alone.[2] While BCAs aim to capture the cost of emissions in the production of goods, consumption charges aim to restore prices signals on the use

[1] A comprehensive view of design elements is provided by, for example Mehling et al. (2017), Carbon Trust (2010), Cosbey et al. (2012), Mehling et al. (2019), and Cosbey et al. (2019).
[2] For a more detailed understanding of policy design, see Neuhoff et al. (2016) and Ismer et al. (2016).

of goods. No jurisdiction has implemented consumption charges on carbon-intensive industrial materials, but consumption charges have been implemented on other emissions-intensive activities or products, such as fossil fuels and electricity generation.[3] Here we focus on consumption charges applied in a system of free allocation, where they would be designed to pass on carbon costs that are otherwise blunted through leakage provisions.

Domestic firms from sectors covered by the consumption charge would have to report their production volumes and would be held liable for the consumption charges due. Producers would either pay the charges themselves or reflect the charges in their pricing at the point of sale for intermediate consumption. Duty-suspension arrangements provide an option for qualifying firms to forego consumption charges if their materials or the subsequent product will be exported. The liability for imported materials subject to consumption charges would be equivalent. Ensuring compliance would require integrating the liability for relevant product categories in the implementing jurisdiction's existing tariff system and establishing accounting and reporting systems that are not overly burdensome relative to obligations for domestic producers.

As an internal charge resembling a value-added tax assessed on domestic production and imports alike using the same product benchmark, consumption charges may prove more robust to WTO challenges than BCA, depending on the BCA's design. They may also be administratively simpler, given that many jurisdictions already have extensive experience with value-added and excise taxes, along with the infrastructure to collect them. However, the extension of consumption charges to imports farther down the value chain that contain significant portions of covered materials would increase the administrative demands of the system, depending on inclusion thresholds and data availability. This potential for trade distortions farther down the value chain in response to unilateral leakage measures is a risk for BCA as well.

A key challenge with consumption charges is the scheme's leakage protections would depend on future levels of free allocation. If declining free allocation outpaces abatement from industrial sectors, continued discrepancies in carbon pricing among key trading partners could still trigger leakage risk. In that circumstance, jurisdictions implementing consumption charges may need to consider other means of industry compensation to fully guard against potential carbon leakage, make changes to the distribution of allowances to prioritize certain sectors, or transition to an instrument that levels differences in carbon costs among trading partners.

Furthermore, as price discrepancies are not levelled at the border, their potential to incentivize abatement outside of the implementing jurisdiction may be limited. Trading partners would have little reason to phase out free allocation if they would face consumption charges for their exports to a jurisdiction implementing consumption charges on top of their own domestic carbon price.

ADDITIONAL POLICIES SUPPORTING DECARBONIZATION

Deep industrial decarbonization will require additional policies beyond carbon pricing. In some instances, carbon prices may be below what is required to incentivize certain technologies and are subject to considerable uncertainty, while low-carbon investments for emissions-intensive industry are capital-intensive

[3] See Munnings et al. (2016) and Raffaty and Grubb (2018) for an overview of other consumption charges.

and come with long-term costs. The potential for investment offshoring that leads to leakage from a loss of long-term competitiveness also underscores the need for additional policies targeting emissions-intensive industries. These factors, compounded with the need for more innovation in breakthrough industrial technologies, underscore the need for additional supporting policies, which are explored in chapter six.

Subsidies to support the deployment and development of **low-carbon technologies** for industry are one way to address some of these problems. The market for low-carbon technologies in other sectors – particularly transport, buildings, and energy – is far more advanced than for heavy industry, owing to more concerted government policies spanning decades (Åhman et al., 2017; IEA, 2019b). Growing awareness of these challenges is leading to greater policy focus. For example, the EU ETS Innovation Fund will prioritize demonstration projects for industrial sectors for the first time starting 2021, and InvestEU envisions supporting successful projects from the Innovation Fund to scale up. Québec plans to combine reductions in free allocation with dedicated funding to support mitigation for EITE entities (ICAP, 2020), along with significant additional budgetary support for industrial decarbonization. The EU is also considering placing conditions on indirect cost compensation for Phase IV of the EU ETS that would require additional investment in low-carbon technologies and production processes to receive aid (European Commission, 2020).

A policy more squarely aimed at deployment of promising technologies are **carbon contracts for difference** (CCfDs). CCfDs offer a way to reduce risk in capital-intensive projects by effectively guaranteeing a certain return for the incremental costs of an investment that delivers emissions reductions below the current best available technology. As developed by Richstein (2017), CCfDs pay out the difference between a reference price (e.g. the yearly average allowance price) and a price agreed to in the contract, effectively guaranteeing a certain level of revenue for the incremental costs of the investment (see also Neuhoff et al., 2019, and Sartor & Bataille, 2019). If the reference price exceeds the contract price, the investor would pay back the difference.

Product carbon standards (PCRs) may be another tool that would incentivize both greener consumption and production, especially if the standards were made mandatory after an initial voluntary phase. PCRs for industrial commodities have not been extensively studied[4] but in essence would begin with labelling standards for certain industrial products linked to their emissions intensity, starting on a voluntary basis initially. In a second phase, the implementing jurisdiction could establish mandatory PCRs that would limit the sale of basic materials to those that meet a certain threshold of emissions intensity. Such an approach would likely only take place in the later stages of an industrial decarbonization process, once there is enough capacity to produce low-carbon materials.

Each of these policies would come with varying challenges, whether trade-based in the case of product carbon standards or raising equity concerns in the case of CCfDs, which would require significant amounts of capital made available to industrial sectors. But given the scale of the challenge, particularly on technology, they warrant further consideration.

[4] For the most extensive proposal to date, see Gerres et al., (2019)

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Acronyms

BCA	Border carbon adjustment
CARB	California Air Resources Board
CCfD	Carbon contract for difference
CCS	Carbon capture and sequestration
EAF	Electric arc furnace
EITE	Emissions-intensive, trade-exposed
ETS	Emissions trading system
EU ETS	European Union Emissions Trading System
GATT	General Agreement on Tariffs and Trade
GHG	Greenhouse gas
HHI	Herfindahl-Hirschman Index
IPCC	Intergovernmental Panel on Climate Change
MELCC	Québec Ministry of Sustainable Development, Environment and the Fight against Climate Change
NDC	Nationally Determined Contribution
NER	New Entrants Reserve
NET	Negative emission technology
OBA	Output based allocation
PCR	Product carbon requirements
R&D	Research and development
RGGI	Regional Greenhouse Gas Initiative
SCM	Subsidies and Countervailing Measures
TBT	Technical Barriers to Trade
WTO	World Trade Organization

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1 Introduction

To avoid the most severe social, economic, and environmental impacts of dangerous climate change, the parties to the Paris Agreement committed to keep global warming to well below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 degrees Celsius. Attaining this goal requires a deep decarbonization of the global economy. Indeed, the Intergovernmental Panel on Climate Change (IPCC) has stressed that the window of opportunity to limit global warming to the agreed goals is closing fast (IPCC, 2019). In response, parties to the Paris Agreement have pledged emission-reduction commitments through their Nationally Determined Contributions (NDCs) and are also developing long-term reduction plans. Some Parties have already legislated or begun processes to set binding net-zero targets.[5]

While much attention has been placed on the important role that the electricity sector will play, over the medium to long term industrial sectors will be equally important to the decarbonization effort. However, following a brief period of stable emissions, global industrial emissions have grown in recent years and reached an all-time high in 2018 (Le Quere et al., 2018).

Emissions trading is emerging as an instrument of choice to achieve reduction targets in a growing number of jurisdictions. Global emissions coverage under some form of emissions trading system (ETS) is expected to reach almost 15% in 2020 with the start of the Chinese national system, an increase of three-fold from 2005 (ICAP, 2020). As of 2020, there were 21 systems in place and a further 24 systems either planned or under consideration. Given that industry is characterized by large concentrated sources of greenhouse gases (GHGs), with producers sensitive to input costs, it is well suited for coverage under an ETS (Hayes & Hafstead, 2020; Burke et al., 2019).[6]

An ETS is a market-based mechanism that is applied to achieve compliance with emissions targets at least cost. By fixing a quantity of emissions (the cap), requiring that companies surrender one allowance for each unit of emissions generated, auctioning or distributing allowances, and making them tradable, a carbon market is created through which an allowance price emerges. For producers, the allowance price is treated as a marginal cost in operational decisions and is a commodity that needs to be reflected in investment appraisals. It encourages them to optimize their operations with a view to the system-wide emissions constraint. Over time, low-emissions products will gain market share over high-emissions products. For final and intermediate consumers, carbon-intensive goods become more expensive, encouraging a switch to low-carbon alternatives or a change in consumption patterns. The relative change in prices creates incentives to invest in low-carbon assets and to develop new products, processes, and technologies that use carbon more efficiently.

In the absence of a homogeneous global carbon price, differences in domestic carbon prices and the associated changes to production costs across jurisdictions can give rise to competitiveness and carbon leakage concerns. While there are wide-ranging differences in how “competitiveness” is defined, especially at

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[5] Sweden, the United Kingdom, New Zealand, France, and Denmark have all passed legislation to achieve net-zero emissions by 2050. The European Union, Spain, Chile, and Fiji have proposed legislation with net-zero targets, and a further nine countries have referenced climate neutrality in policy documents (Net Zero Tracker, 2020).

[6] For a discussion on the role of carbon pricing across different sectors, see Burke et al. (2019).

varying levels of economic analysis, here we refer to it is as the capability of domestic firms to maintain market shares and profitability (Berger, 2008). Where higher production costs put domestic industrial producers at a competitive disadvantage, they can lose market share to foreign competitors or shift their own production and future investments to regions that do not have costs related to GHG emissions. Research shows many factors are at play in decisions for companies to invest or relocate (e.g. tax rates, labor costs, geographic location), but the focus of this paper is on carbon leakage that could result from differentials in carbon pricing (Arlinghaus, 2015; Jaffe et al., 1995; Ekins & Speck, 2010).

Carbon leakage threatens the environmental effectiveness of domestic climate policy if emissions simply shift offshore. In the worst case, global emissions may increase if production shifts to regions with relatively higher carbon intensities (Fowlie & Reguant, 2016). At the same time, the shifting competitiveness associated with carbon leakage creates significant economic, social, and political challenges. The combination of these factors makes carbon leakage one of the most contentious and important aspects of ETS policy design.

To date, all jurisdictions that have implemented an ETS have done so with provisions to protect against carbon leakage. Metrics are applied to assess which industries are most at risk of carbon leakage, and qualifying sectors receive a quantity of allowances free of charge. However, the future longevity of such an approach will be constrained by at least three factors.

First, allowance budgets will decline in line with carbon neutrality (net-zero) targets. As mitigation efforts scale up and caps decline, the quantity of allowances that can be allocated for free will also decline, constraining ongoing free allocation as a carbon leakage response in the long term.

Second, free allocation can distort investments, innovation, and downstream mitigation options. Apart from affecting the degree to which firms pass on their carbon costs and competitiveness, free allocation rules also affect the relative attractiveness of investments into different sectors and mitigation technologies. The more carbon prices increase, the more important it becomes that allocation rules do not bias investment in undesirable directions, e.g. disadvantaging cleaner alternatives to emissions-intensive products because their embodied emissions are not fully priced or because the more emissions-intensive technology receives a lower carbon cost due to higher free allocation. Finally, free allocation that adjusts per unit could also limit incentives for downstream mitigation opportunities, such as substitutions to less carbon-intensive materials or demand reduction. By restricting the number of abatement opportunities incentivized, the cost efficiency of carbon pricing is reduced, making it harder to achieve ambitious mitigation targets.

Finally, the carbon pricing landscape is changing. Current leakage provisions typically assume that domestic carbon pricing occurs in isolation, but achieving the emission-reduction targets outlined under the Paris Agreement will require strict carbon constraints across all regions and sectors globally. This is not to say that carbon leakage is no longer a concern in a Paris world. To the contrary, as jurisdictions move at different paces in stepping up the ambition of their domestic climate policies, it is likely that carbon costs will vary significantly (Neuhoff et al., 2015; Mehling et al., 2019). However, the relevant consideration is increasingly no longer whether a jurisdiction imposes carbon pricing and at what level but rather its pricing level *compared* to major trading partners and how other carbon-pricing jurisdictions apply free allocation and exemptions to protect their EITE industries from carbon leakage.

The deployment of negative emission technologies (NETs) in the coming decades to achieve climate stabilization will impact decarbonization strategies for industrial sectors, especially given their expected costs and political challenges. This paper does not focus on this aspect of the decarbonization challenge but acknowledges the deployment of NETs as an important area of future research.

In this report, we focus on basic materials sectors (e.g. cement, iron and steel, chemicals, pulp and paper, and aluminum). Basic industrial materials produced with conventional technologies require large inputs of fossil fuels in the production process and release GHGs through the conversion of raw materials to products, making them highly emissions intensive. They are also low added value, homogeneous products that are traded in competitive global markets. Therefore, they are considered EITE and at risk of carbon leakage by all existing ETSs.

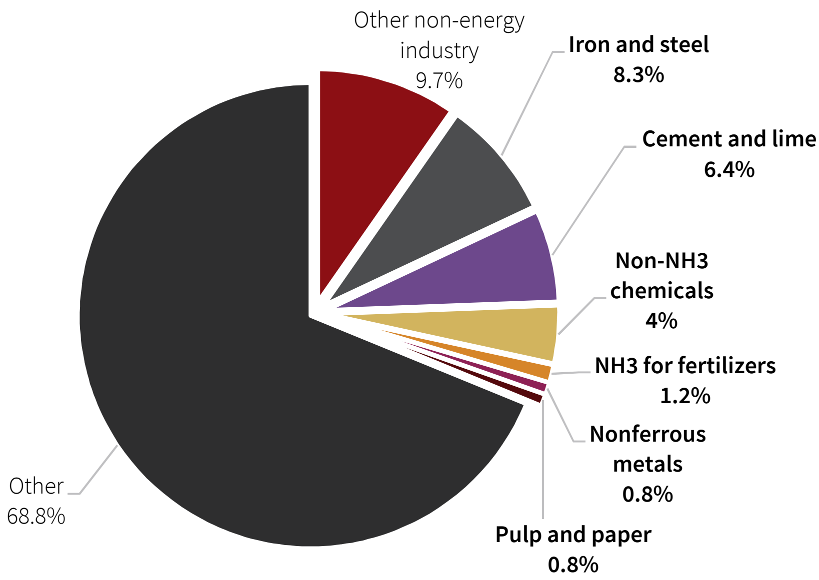
The report is structured as follows. Chapter two considers the decarbonization challenge for the basic materials sectors and develops a conceptual framework for assessing the compatibility of carbon leakage provisions in driving deep decarbonization. Chapter three assesses current approaches to free allocation against this framework. Chapter four takes a critical review of carbon leakage risk assessment. In Chapter five, alternative approaches for carbon leakage protection are assessed against the framework developed in chapter two. As decarbonization will require additional measures to complement carbon pricing as part of a broader strategy targeting industry, chapter six provides a preliminary discussion of enabling policies. Chapter seven offers some conclusions.

2 Carbon pricing and deep industrial decarbonization

2.1 THE INDUSTRY DECARBONIZATION CHALLENGE

Holding average temperature increase to well below 2 degrees Celsius and avoiding catastrophic climate change will require energy and industrial sectors to achieve net-zero emissions (IPCC, 2019). While significant decarbonization of the electricity sector has begun, emission reductions from industrial sectors has been limited (Neuhoff et al., 2018; Le Quere et al., 2018; Marcu et al., 2019). This lack of progress is concerning, particularly given the contrast between the emission-reduction efforts required and the growing global demand for basic materials from industrial sectors that is required for global economic and social development (IEA, 2019a). The production of basic materials accounted for around 22% of global CO_2 emissions in 2016 (Bataille, 2019; see Figure 2.1.). Steel production has increased 40% over the last 10 years; cement production 46% over a similar period; and global plastics demand is doubling about every 20 years (Material Economics, 2018; USGS, 2020). With current patterns of material growth, it is estimated that global demand for basic materials will increase two-to-fourfold over the course of this century (Material Economics, 2018).

Figure 2.1: Percentage contribution of basic materials in global combustion and process CO2 emissions



Source: Bataille, 2019.

Delivering emission reductions from these sectors faces three key challenges. First, current core processes in basic material production often require temperatures in the range of 850–1,600°C, entailing constraints on the types of energy sources that can be used based on current technologies. While electricity can be used in some cases (e.g., electric arc furnaces (EAFs) used in steel making), opportunities for electrification are limited, because it might be technically infeasible with current technologies and processes or unprofitable at current carbon and energy prices. Second, GHG emissions come not only from energy use but also through chemical transformations that take place in the production of many basic materials (e.g. clinker in cement manufacturing and the removal of oxygen from iron ore in steel making).[7] Finally, particularly for plastics, GHGs are emitted through decay or incineration at the end of the product's life (Material Economics, 2019).

Because of these challenges, and as reinforced by industrial decarbonization analysis (Bataille, 2019; ETC, 2018; Material Economics, 2019), net zero will not be possible without both demand and supply side reduction measures (Table 2.1). On the supply side, incremental improvements to existing production processes will be necessary, including:

- replacing fossil fuels for heating with renewable electricity (although at this stage it appears that this will be mostly limited to expanded EAF steel making) and hydrogen;
- replacing fossil fuels with sustainably produced biomass; and
- increasing the efficiency at which heat and energy are used within the production process.

However, innovations and new production techniques will also be necessary to reach net zero, including:

- incremental improvements in existing technologies (e.g. blending clinker with slag ash or other waste materials);
- new low-carbon production processes (e.g. hydrogen-based steelmaking, new routes for plastics synthesis, inert anode technology to produce aluminum); and
- scaled up carbon capture and storage;
- negative emission technologies to compensate for residual emissions (Material Economics, 2018; ETC, 2018; McKinsey & Company, 2018)

Table 2.1: Mitigation opportunities from the industrial sectors

Supply		Demand	
Fuel switching and production efficiency	**Innovations in the production process**	**Material substitution**	**Low carbon consumption**
• Low to medium heating through renewables • Replacing the fossil fuel feedstock with sustainably produced biomass • Increasing the efficiency of production	• Incremental improvements in existing technologies • New low carbon production processes • Carbon capture and storage • Negative emission technologies	• Increased recycling • Improved (intermediate) production process • Substituting low carbon alternatives for high carbon materials	• Higher end use of products • Improved product design

Source: based on Neuhoff et al., 2018; Material Economics, 2018; ETC, 2018.

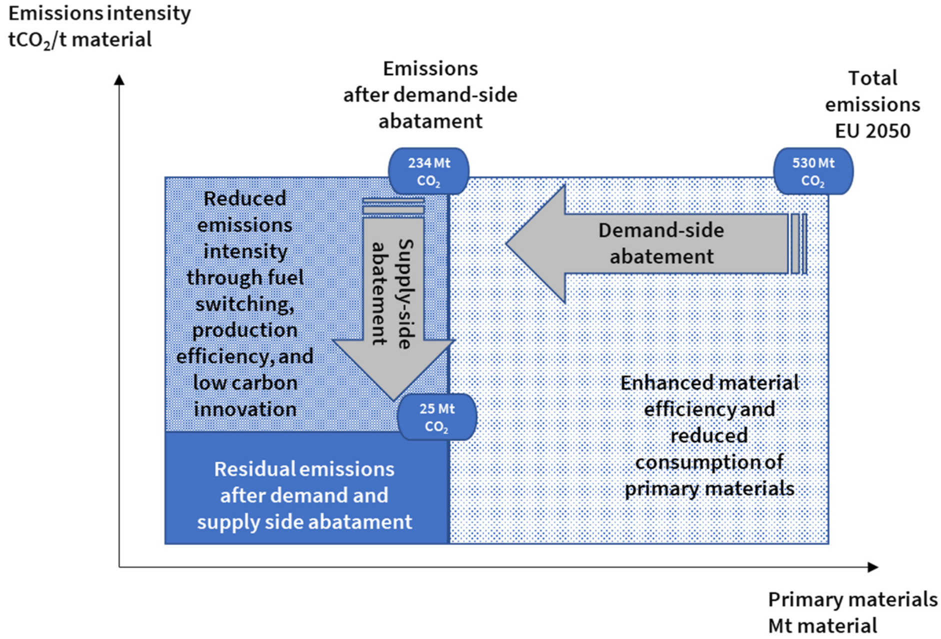
[7] In cement manufacturing carbonates are decomposed to oxides and CO2 by the addition of heat. In steel making, carbon is used to remove oxygen from iron ore to produce iron.

While the importance of incremental efficiency improvements of conventional production processes should not be downplayed, they are unlikely to result in large emission cuts for basic materials sectors. Therefore, much of the abatement potential on the supply side will come from shifting to production processes based on renewable energy (electrolysis or directly hydrogen-produced from renewable energies) as well as carbon capture and storage (Material Economics, 2018; Philibert/IEA, 2017; Bataille et al., 2018). These promising technologies hold great potential for emission reductions but are currently far from commercial use.

On the demand side, a large suite of options is available to reduce the use of emissions-intensive materials, thereby narrowing the emissions gap that needs to be closed by the supply side measures outlined above (Material Economics, 2018; Rissman et al., 2020). First, increasing the recycling rate of primary materials will reduce the demand for new materials. Second, improving product design can achieve the same services with less inputs of (primary) materials. Third, improvements to the production process of final or intermediate goods can reduce waste along the supply chain, reducing demand for basic materials (Horton & Allwood, 2017). Fourth, shifts in the way we use end products (particularly buildings and cars) can increase the benefits derived from primary materials and extend their lifespans (Material Economics, 2018). Finally, substitution away from high-carbon materials towards low-carbon alternatives presents further abatement opportunities (e.g. scaled-up use of lightweight materials, replacing steel and cement with wood).

Figure 2.2 shows the critical relationship between supply-side and demand-side mitigation measures. Given the challenge to decarbonize the supply of carbon-intensive basic materials, reducing their demand will be a critical part of the policy response. Taking the example of the EU, it is estimated that over 50 percent of the reduction challenge can be achieved through demand-side measures (Material Economics, 2019). The conclusion is that any policy response to address carbon leakage will necessarily need to also drive a reduction in both the demand for and supply of carbon-intensive basic materials.

Figure 2.2: Percentage contribution of basic materials in global combustion and process CO2 emissions



Source: based on Material Economics, 2019.

2.2 THE ROLE OF CARBON PRICING

Carbon pricing can drive each of the mitigation levers discussed above. Higher carbon prices will make carbon-intensive inputs such as fossil fuels more expensive, providing an incentive to use them more efficiently and/or to shift towards low-carbon alternatives. It will also encourage producers to seek carbon efficiencies in the production process, including through new investments. On the demand-side, carbon pricing will often (and ideally) make carbon-intensive intermediate goods more expensive, encouraging a switch to low-carbon alternatives or a change in consumption patterns. Pauliuk et al. (2016) find that a carbon price of €30 per ton of CO_2., if passed onto product prices, would lead to a 28% increase in the price of cement, 11% increase in the price of steel, and 6% in the price of plastics. Such price increases could result in significant changes in the production process of final goods by creating an incentive for efficient material use in the design and production of basic materials, making low carbon alternative more attractive and increasing incentives for recycling. Higher prices also ensure that the incremental costs of innovative, low-carbon production processes can be recovered (Neuhoff et al. 2015). Lastly, revenues from carbon pricing can be used to support the development and deployment of new mitigation technologies as well as negative-emission technologies.

Table 2.2: Optimal carbon pricing for the basic materials sector

Supply		Demand	
Fuel switching and production efficiency	Innovations in the production process	Material substitution	Low carbon consumption
• Incentives for producers to lower carbon intensity of their inputs and final products	• Low-carbon innovations earn margins in product market • Incremental cost of low-carbon investments recovered	• Make low carbon products competitive; • Increase incentives for recycling	• Encourage consumers to use products more efficiently or switch to low carbon alternatives

Source: Based on Neuhoff et al., 2018.

2.3 CARBON PRICING AND CARBON LEAKAGE

Attempts to price carbon have so far been met with the same concern: in the absence of a global carbon market (or global carbon price), differences in carbon prices and the associated changes to production costs across jurisdictions give rise to carbon leakage concerns. Where higher production costs put domestic industrial producers at a competitive disadvantage, they can lose market share to foreign competitors or shift their own production and future investments to regions that do not have costs related to GHG emissions. Carbon leakage threatens the environmental effectiveness of domestic climate policy where emissions simply shift offshore. In the worst case, global emissions may increase if emissions shift to regions with higher carbon intensities (Fowlie & Reguant, 2018; Branger & Quirion, 2015). At the same time carbon leakage creates significant economic, social, and political challenges. Carbon leakage and the broader shift to a climate-neutral economy pose disruptions to long-established industries, with implications for employment in vulnerable sectors and unequal distributions of opportunities and economic dislocation (CPLC, 2019).

There are three channels through which carbon leakage might occur (see e.g. Cosbey et al., 2019; Fowlie & Reguant, 2018).

1. **Output (short-term competitiveness) channel**: allowance prices increase direct and indirect costs for domestic producers but not for foreign competitors. Domestic firms lose market share to the benefit of unconstrained competitors.

2. **Investment (long-term competitiveness) channel**: over the long term, investment moves offshore due to differences in expected returns. Plants in carbon-pricing jurisdictions close and are replaced by plants in jurisdictions with less or no constraints, or plants remain in operation in the carbon-pricing jurisdiction but marginal increases in capacity move to third countries with fewer emissions constraints.

3. **Energy market channel**: a reduction in demand for fossil fuels in carbon-constrained regions lowers global energy prices, resulting in a rebound effect in unconstrained regions.

A growing body of research seeks to understand if carbon leakage occurs. Unfortunately, it is difficult to draw strong conclusions from this work. On the one hand, *ex ante* general and partial equilibrium modelling provides a wide range of leakage rates for different industries and regions, with the specific numbers often varying with underlying modelling assumptions on market structure and trade dynamics. Additionally, there is a significant body of ex-ante modelling that has identified leakage through the energy-market channel as the most persistent source of leakage, often exceeding that of the output and investment channels (Zachmann & McWilliams, 2020). On the other hand, *ex post* analysis of existing policies and real-world experiences find little to no evidence of carbon leakage (see appendix for a review of this literature).

Several factors have been put forward to understand the divergence of results between expected and actual leakage rates. First, carbon prices have been relatively low to date, typically between ~€5 and ~€30. At this level, prices are unlikely to affect competitiveness and may not have been considered in investment decisions, which instead are more likely to be driven by factors such as tax rates, labor availability, market dynamics, and infrastructure (CPLC, 2019; Fischer & Fox, 2018). Relatively low prices to date may have at times reflected an approach by governments that utilizes additional companion policies (e.g. renewable energy targets) to drive mitigation given the social and political costs of relying on high carbon prices alone. Second, all existing carbon pricing mechanisms have protected those sectors considered to be most at risk of carbon leakage with either free allocation, rebates, or exemptions. Third, most studies focus on short-term leakage, whereas competitiveness issues that ultimately lead to industry relocation and carbon leakage are more likely to occur in the long term.

A further challenge in identifying carbon leakage is that the aim of ambitious climate policy is to support low-emissions firms to become more competitive against high-emissions firms. Regions with higher carbon prices and more stringent climate policy will provide a competitive environment for new, low -and zero-carbon industries (CPLC, 2019). Firms that innovate first may find a competitive advantage in new, low-carbon marketplaces. Indeed, recent research from the OECD (Ellis et al., 2019) found positive effects of carbon pricing on firms' competitiveness. From a low-carbon transition perspective, this positive dynamic must be distinguished from carbon leakage (CPLC, 2019).

Based on the literature to date it is therefore difficult to fully understand how large the risk of carbon leakage would be under more ambitious and widespread carbon pricing. That said, given the bottom-up nature of the Paris Agreement, with different parties committing to different carbon constraints and placing a different emphasis on carbon pricing in the policy mix, differences in carbon prices and allocation rules are likely to continue and even grow over the medium to long term (Mehling et al., 2019; Neuhoff et al., 2015).

2.4 CARBON LEAKAGE AND DEEP DECARBONIZATION ASSESSMENT FRAMEWORK

Considering the above dynamics, carbon leakage concerns create a conundrum for carbon-pricing policies. On the one hand, passing on carbon costs into the price of basic materials is essential for unlocking the mitigation potential of these sectors and for creating new, low-carbon product markets. On the other, increased prices as a result of climate policy could drive leakage in sectors exposed to international trade, eroding the environmental effectiveness of the policy—but the extent of this risk, and when it may materialize, is uncertain. With this in mind, leakage protection measures that accompany polices aiming to drive long-term, deep decarbonization will likely need to balance three objectives: continued protection against carbon leakage, compatibility with long-term transition, and political durability (see the table below). In the following chapters, we assess different responses to carbon leakage against this framework.

Table 2.3: Carbon leakage and deep decarbonization assessment criteria

Protection against carbon leakage	Compatibility with long-term transition			Political durability		
Addressing risks of leakage and loss of competitiveness	Low-carbon production (fuel-switching, production processes)	Low-carbon consumption (material efficiency)	Developing new technologies and markets for those technologies to take root	International acceptance	Ease of implementation	Other

3 Free allocation as an approach to leakage protection

Free allowance allocation is a feature of almost every operating ETS.[8] Free allocation can be provided based on only historical emissions (grandparenting); historical production levels with an efficiency benchmark (fixed sector benchmarking); or based on actual production and an efficiency benchmark (output-based allocation). Discount factors may be applied to bring free allocation in line with the cap trajectory or to differentiate free allocation among sectors based on carbon leakage risk. Regardless of the method, free allocation reduces the carbon costs for those that receive allowances and may impact both production and investment decisions.

From a carbon leakage perspective, both marginal and average cost impacts are important for output decisions and the extent to which domestic firms might lose market share to the benefit of unconstrained competitors. In the short term, marginal carbon costs drive the degree to which capacity may be utilized. Differences in marginal carbon costs between domestic and foreign producers can lead to a loss of short-term competitiveness and leakage through the output channel of leakage referred to in chapter two. Over the longer term, average carbon costs will be of importance for investment decisions and can lead to leakage through the offshoring of investment to jurisdictions with fewer constraints, referred to as the investment channel of leakage in chapter two. Explicit or "market" prices are important to ensure that the opportunity cost of carbon is included in marginal costs. Free allocation rules determine to what extent average production costs will reflect the value of embodied carbon. Furthermore, the actual implementation of different allocation methods can also create different distortions or perverse incentives.

When selecting the method for free allocation, policymakers need to balance multiple objectives. Particularly in the early phases of ETS implementation, free allocation can assist the transition to an ETS and provide compensation for the devaluation of assets that have been invested in the past (CARB, 2010a). Similarly, recognizing that an ETS takes time to establish, free allocation can be designed in a way to reward those entities that reduce their emissions before the ETS is fully established (early action). In addition, policymakers may target free allocation to adversely affected stakeholder groups to secure political buy-in or to resolve other distributional concerns. In doing so, allowances can be granted to non-regulated entities with guidance on how the revenues from allowance sales are to be used (consignment auctions) (see for example Burtraw & McCormak, 2016).

However, as markets mature, the need for transitional assistance declines and free allocation tends to be more targeted at reducing carbon leakage concerns (Flues & van Dender, 2017; CARB, 2010a). In this way, markets tend to progress from an initial grandparenting of allowances, which is easier to implement because only historic emissions data need to be collected and verified, to more data- and resource-intensive benchmarking approaches, either fixed sector benchmarking or output-based allocation (see Table 3.1 for a summary of approaches across ETS jurisdictions).

In this chapter, we first introduce different methods for awarding allowances free of charge. We then compare these methods in terms of their ability to offer leakage assistance while at the same time drive deep decarbonization in a way that is politically durable (see table 3.2).

[8] RGGI focuses only on the power sector and does not allocate allowances free of charge.

Table 3.1: Summary of approaches to free allocation across key jurisdictions

	% of allowances allocated freely	Sectors receiving free allocation	Launch date	Benchmarking introduced	Primary allocation method
EU Phase (III): 2012-20	~43%	Industrial sectors and aviation. No free allocation for electricity production (with exception of some newer and lower-income EU member states).	2005	2008; expanded as from 2013	Fixed baseline period benchmarking
EU Phase (I & II): 2005-07	Minor share	Power generators, manufacturing	2005	2008; expanded as from 2013	Large share of grandparenting; increasing fixed baseline period benchmarking
California	~50%	Industrial activities; investor-owned electric distribution utilities and natural gas suppliers must consign free allowances to auction.	2012	2013; expanded as from 2014	Output-based benchmarking for industrial sectors (12%); historical emissions with a cap adjustment factor, customer cost burdens, or other factors for utilities (40%).
Québec	~30%	Industrial activities and electricity production if procurement contract was signed prior to 2008. No free allocation for fuel distributors.	2013	2013	Output-based benchmarking with declining adjustment factor based on type of emissions (e.g. fixed process, combustion)
New Zealand	~21%	Industrial activities exposed to transoceanic trade; fishing and forestry	2008	2010	Output-based benchmarking (industry); one-off free allocation to forestry and fishing (form of grandparenting)
Republic of Korea	~97% (decreasing to ~90 from 2021-2025)	All sectors in phase 2 (2018-2020) and 3 (2021-2025); non-EITE sectors required to purchase portion of allowances at auction.	2015	2015: expanded as from 2018 and further starting 2021	Grandparenting and fixed baseline period benchmarking; benchmarking to reach 70% during Phase 3 from 50% in Phase 2

3.1 APPROACHES TO FREE ALLOCATION

3.1.1 Grandparenting

Under grandparenting, firms receive allowances freely according to their historical emissions or fuel input multiplied by an emissions factor. Grandparenting results in a lump-sum transfer to firms in which the allocation is unrelated to their current levels of output or emissions; as such, incentives should not be affected at the margin (Böhringer & Lange, 2005; Fischer & Fox, 2007). Firms that receive more allowances than they require can sell any surplus allowances for profit. Those that emit more than they are allocated will have to purchase additional allowances at auction or from the market. In both cases, allocated allowances come with an opportunity cost that might encourage firms to reduce their production as one method to reduce emissions. In other words, although the allowances are free, the full opportunity cost they represent will still be passed on to consumers, who will decrease their consumption of the product or look elsewhere. In practice, the fine print of grandparenting arrangements has often included some form of updating provisions that, as explained later in this chapter (section 3.2.2), can distort long-run incentives. This can also be the case with fixed sector benchmarking. Prominent examples of grandparenting include the first two phases of the EU ETS, the first phase of the Korean ETS (for most sectors), and various Chinese ETS pilots (PMR, 2015).

3.1.2 Output-based allocation

Under output-based allocation (OBA), firms receive assistance based on their actual (or very recent) production levels multiplied by a sector-specific emissions benchmark. This has two important implications. First, the allowance allocation is more closely targeted to allowance requirement overall. If production increases, so too will levels of free allocation; if production declines, a proportion of allocation will be removed. Second, as allocation adapts to production levels, OBA acts as a subsidy and thus encourages additional production at the margin (Fischer, 2019; Fischer & Fox, 2007). The size of the subsidy depends on where the benchmark is set as well as other details such as assistance factors and cap decline factors. In turn, higher levels of output and less cost pass-through result in lower product prices compared to other approaches where producers pass on the full opportunity costs of carbon (Fischer, 2019; Flues & van Dender, 2017). OBA is used in California, Québec, and New Zealand. Variants of this approach are also used in Canada's Output Based Pricing System (Fischer, 2019).

3.1.3 Fixed baseline period (sector) benchmarking

Under fixed baseline period benchmarking,[9] the number of allowances an entity receives is a function of a product-based benchmark combined with installation-specific historic activity levels for a fixed baseline period. In this way, it is a hybrid between full OBA and grandparenting. It is like grandparenting in that allocation is not adjusted frequently to changes in output. However, it differs in that assistance levels are tied to an individual firm's historical production and not its historical emissions. The more frequently the activity levels are updated, the closer the approach comes to OBA. Fixed baseline period benchmarking is applied in phases III and IV of the EU ETS as well as the Korean ETS.

Under fixed sector benchmarking and OBA, producers will be encouraged to reduce their emissions up until the point where the marginal cost of doing so is equivalent to the allowance price (Goulder & Schein, 2013).

[9] Also referred to as fixed sectoral benchmarking

Facilities that perform more efficiently than the benchmark will receive more allowances than they need and can sell the remainder on the secondary market. Therefore, regardless of where the benchmark is set, firms should always have an incentive to reduce the carbon intensity of their production, as well as to pass along the opportunity costs of the emissions associated with their production. Unlike OBA, with fixed sector benchmarking the number of allowances firms need depends on current output and emissions intensity compared to the benchmark *and* historic activity levels. Installations that perform less efficiently than the benchmark—or have production levels higher than their baseline—will face a shortage and will therefore need to increase their efficiency, purchase additional allowances, or reduce output.

3.2 FREE ALLOCATION AND DEEP DECARBONIZATION

3.2.1 Protection against carbon leakage

OBA offers strong protection against short-term carbon leakage assuming benchmarks are not significantly lower than the sector or facility's performance. Unlike grandparenting or fixed-baseline allocation, OBA adjusts allowances based on recent activity levels. Therefore, average carbon costs are offset at the margin for output, and firms can increase production despite competitive pressure from firms that do not face a carbon price (Fischer, 2019; Fischer & Fox, 2007; PMR-ICAP, 2015).

The extent of leakage protection under OBA will depend on how well the allocation makes up for the policy-induced average cost difference between domestic firms and competitors. This difference depends on the gap between actual carbon intensity and the benchmark level of carbon intensity (i.e., how much remaining carbon is priced), the extent to which carbon-reducing technologies increase production costs, and to what extent other jurisdictions price carbon (and pass through those costs) in their industrial sectors. As such, significant differences in allowance prices and benchmarks across carbon pricing jurisdictions may drive long-term competitiveness impacts, even where OBA is present. For example, a comparison of product-based benchmarks between California and Europe reveals substantial differences in benchmark values for some product categories (Flues & van Dender, 2017).

In contrast, **grandparenting**—in its purest form, without updating—may be ineffective at protecting against carbon leakage. As the full opportunity cost of allowances is preserved, firms may be encouraged to reduce their production to reduce emissions. Reducing output for a given demand will result in price increases, encouraging consumers to decrease their consumption, assuming reduced domestic output does not result in increased imports. However, the use of grandparenting has often come with provisions to update allocation based on more recent levels of output, which provides stronger leakage protections by creating a stronger link between current production and allocation.

Fixed baseline period benchmarking performs in a similar way to grandparenting. If no adjustments are made to the baseline activity levels utilized for allocation, then trade-exposed firms may still reduce production in response to the allowance price signal and lose market share to international competitors (Vivid Economics, 2018; PMR-ICAP, 2016). As such, where fixed baseline benchmarking has been applied, it has been supplemented with closure rules and updating provisions that provide a stronger incentive to maintain output (and hence reduce leakage). For instance, Phase III of the EU ETS allowed for adjustments for new entrants, plant capacity increases and reductions, plant closures, and the partial reduction or recommencement of activity. Facilities face a reduction of 50%, 75%, or 100% of their allocation if their production falls below 50%, 25%, or 10% of their baseline activity levels, respectively (Branger et al., 2015). Fixed baseline period benchmarking will provide stronger leakage protection the more frequently allocations are adjusted to reflect changes in production (and hence the more it becomes like OBA).

3.2.2 Compatibility with long-term transition

Under **grandparenting**, firms should respond to the allowance price in the same way as they would have if they were required to purchase all the allowances they need. That is, the full opportunity cost of allowances will enter production and investment decisions, and firms that are not trade-exposed will increase their product prices to reflect higher costs, thereby triggering downstream abatement. For these firms, free allocation via grandparenting in the absence of updating will provide an undistorted allowance price signal and an efficient abatement response.

However, most ETSs have updating provisions to allocation both between and within phases, either directly by changes to the base period or indirectly through new-entrant and plant-closure provisions. Although this has been done with good reasons, especially to reduce windfall profits or to make leakage protection stronger, it can introduce perverse incentives. If entities can foresee or predict that changes in their activities will affect their future allocation, this may distort their production and investment decisions (Zetterberg et al., 2012). For example, if entities know that reduced emissions will result in reduced free allocation in future periods, they might have an incentive to maintain emissions artificially high. The same perverse incentives apply to whatever metric is used to update allocation (e.g. output, capacity) (Böhringer & Lange, 2005).

Under phase II of the EU ETS, allocation was based on Member State “Allocation Plans”. While small shares of auctioning and benchmarking were included, the preferred allocation method was grandparenting. Allocation for new entrants was provided using fuel-specific benchmarks that provided more free allowances for more carbon-intensive fuels, which created a subsidy that favored high-carbon assets over low-carbon ones. Additionally, most allocation plans withdrew allowances from plants upon closure, which encouraged obsolete plants to maintain production and delay their closure (Neuhoff et al., 2006).

Updating is also common with **fixed baseline period** allocation. Updating based on a firm’s output offers better incentives than updating based on a firm’s emissions. However, if free allocation is linked to activity thresholds through plant activity and closure rules, updating might still create some perverse abatement incentives (Neuhoff et al., 2015). For example, in Phase III of the EU ETS, allocation rules require firms to maintain activity levels to at least 50% of that when free allocation rules were set. Allocation is reduced by 50%, 75%, or 100% if annual production falls below 50%, 25%, or 10% respectively. In the face of declining production, these thresholds created incentives for companies to spread production over several sub-installations to maintain the full issuance of free allowances, leading to higher levels of production and GHG emissions (Branger et al., 2015). The EU has sought to address these distortions in Phase IV by allowing allocation to rise or fall by a set proportion in response to a change of more than 15% in activity levels at both the company and sub-installation levels relative to baseline activity levels.

Compared to other methods of free allocation, **OBA** limits carbon price pass-through and therefore incentives for demand-side abatement and low-carbon product innovation (Fischer & Fox, 2007). OBA is effective at incentivizing emissions reductions per unit of output but not the substitution of low-carbon materials, increases in material efficiency, or competing technologies (Branger & Sato, 2017).

The impact of limited carbon price pass-through for leakage-exposed sectors on investment is contested. Fischer (2019) points out that forgiving carbon costs will leave emissions-intensive firms with more cash flow that can be used to finance low-carbon investments. However, Neuhoff et al. (2015) argue that emissions-intensive firms are unlikely to invest in new technologies where the investment and operation costs cannot be recouped by passing on higher carbon costs in product prices. This is because under OBA, and to some extent fixed sector benchmarking with updating, with limited price pass-through of carbon costs to consumers it is challenging to make a business case for investments in low-carbon production, leading to reliance on the ability sell excess allowances, which might be perceived as a less reliable and credible source of revenue for major investments. This implies de facto a cross subsidy from non-protected sectors that must purchase allowances for mitigation investments from leakage-exposed sectors (ibid).

As the sale of free allowances is necessary to cover the investment costs, firms must trust that they will continue to receive free allowances long after the investment has been made (and emissions reduced). This is an increased concern when non-protected sectors have significantly decarbonized and have less need for surplus allowances, or if allocation levels are decreased in response to significant industrial decarbonization. The long-term credibility of such an approach therefore relies on the stability of regulatory arrangements around the provisions of free allocation as well as technology developments and the demand for allowances from other sectors.

Irrespective of the allocation method, whenever firms producing low-carbon alternatives do not qualify for free allocation while their high-carbon alternatives do, these alternatives are disadvantaged and incentives for low-carbon innovation are weakened, unless allowance allocations are truly fixed and unconditional (Flues & van Dender, 2017). For example, non-clinker cement producers are not included in the EU ETS and hence do not benefit from free allowances.[10] The subsidy received by high-carbon producers through free allocation combined with no carbon cost pass-through to product prices stifles the market for low-carbon products, slowing down the low-carbon transition. While this dynamic can be true for any allocation method, OBA makes preferential treatment explicit in the short term. This design problem extends to setting multiple benchmarks for competing products, such as for different production processes (e.g. electric arc furnace versus blast furnace in steel making or fuel specific benchmarks for electricity generation). Where multiple benchmarks are present for a single product (coal and gas for electricity generation), producers will be encouraged to increase their efficiency with respect to the benchmark but may be discouraged to switch to alternative production processes (e.g. from coal to gas).

That said, these distortions are not directly related to the method of allocation but rather the rules in which it is applied. For example, in California emissions intensity is assessed at the sector level, meaning that low-emission cement producers would qualify for free allowances based on their cement production and not be at a disadvantage. Similarly, adhering to a principal of “one product, one benchmark” avoids any distortions created between competing products.

[10] This is because cement activities covered under the EU ETS are defined in terms of their use of clinker. Specifically, the associated Annex 1 activity is “production of cement clinker in rotary kilns with a production capacity exceeding 500 tonnes per day or in other furnaces with a production capacity exceeding 50 tonnes per day”.

3.2.3 Political durability

Grandparenting is simple, transparent, and requires only data on historical emissions or energy use to be implemented. This relative simplicity makes it easier to implement and therefore popular. One-off grandparenting is also an attractive option to provide transitional support for industries that might otherwise lose significant value from stranded assets and is therefore popular among industry (PMR-ICAP, 2016; High Level Commission on Competitiveness, 2019).

Grandparenting will generate windfall profits for firms that can pass on the costs of climate policy (Hintermann, 2014; Goulder et al., 2010; Sijm et al., 2006). Overcompensation can be quite substantial; generally, only a small share of allowances needed for compliance suffices to minimize leakage risk among vulnerable industries (Goulder et al. 2010). The size and persistence of windfall profits can create issues surrounding the perceived fairness of an ETS. For example, consumers may have concerns about paying increased product prices where polluters received allowances for free. Windfall profits will be highest in industries with historically high emissions that have not taken early action, still have access to reasonably cheap abatement options, and have latitude to pass-through carbon costs to consumers (PMR-ICAP, 2016). Large profits reaped by electricity producers became a point of controversy during EU ETS phases I and II (Point Carbon, 2008).

Concerns about windfall profits are also relevant for **fixed baseline period benchmarking**. Because allocation is not based on current output, firms that are less trade-exposed are incentivized to respond to carbon prices by reducing output and increasing prices (Vivid Economics, 2018). Debate continues around the extent to which allowance prices have been incorporated into industrial product prices during Phase III of the EU ETS (Carbon Market Watch, 2016; Marcu et al., 2019; Sandbag, 2017; Neuhoff & Ritz, 2019). Empirical estimates of cost pass-through vary widely by sector, country, and time period and are often statistically insignificant due to large confidence intervals and data-related methodological challenges (Neuhoff & Ritz, 2019). Furthermore, recent estimates of cost pass-through are sparse, with literature that provide a review of estimates drawing mostly from older sources. This empirical uncertainty makes it difficult for policymakers to navigate the tradeoff between windfall profits and leakage protection under free allocation methods that aim to address both. This is of less concern for OBA, where windfall profits are less likely, as assistance is targeted to actual production levels.

Benchmarking under both OBA and fixed baseline period can be a complicated, data-intensive, and lengthy exercise, which may create a barrier for smaller jurisdictions or those without the resources to devote to the process. In addition, information asymmetry between regulators and covered entities can make an assessment of benchmark stringency difficult. These challenges can be overcome by strong institutions, close stakeholder engagement, and formal legal requirements to submit the required information to regulators. Indeed, experience from California, Québec, Ontario, New Zealand, and the EU suggests that the technical challenges to setting benchmarks can be addressed.

OBA may face additional political scrutiny where the environmental outcome of the ETS becomes less certain. The commitment to update allocation proportional to output may place pressure on emission caps, particularly in the face of declining allowance budgets where industrial allocation is a large share of the total allowance budget. While this can be mitigated by strictly limiting OBA to only those sectors at risk of carbon leakage and through increasing the stringency of the benchmarks, this could create additional political challenges from EITE firms, as it will reduce the policy's ability to protect against carbon leakage (Vivid Economics, 2018). The environmental outcome will not come into question where OBA is used for industrial allocation that represents only a small share of the allowance budget. In California, for example, allocation to EITE sectors is only about 12% of the overall allowance budget and declines each year in proportion to the cap using sector-specific adjustment factors. Québec also applies cap adjustment factors to reduce OBA levels in line with the overall cap trajectory.

3.3 IMPLICATIONS FOR CARBON LEAKAGE AND DEEP DECARBONIZATION

At the carbon prices witnessed over the last decade, there is little evidence of carbon leakage,[11] which suggests that free allocation, of various forms, has performed well in offering leakage protection. However, there is tension on the horizon between ongoing free allocation and the cap reduction trajectories that are required to reach deep decarbonization. This tension is acute for systems where industrial emissions make up a significant share of the allowance budget. Systems with an economy wide cap, where industrial emissions are a small share of the allowance budget, are unlikely to face allowance shortages. However, given cap adjustment factors built into free allocation formulas, industrial producers will face increasing carbon costs if mitigation does not keep pace with declining volumes of free allocation. The question then becomes whether those sectors at risk of carbon leakage can reduce their emissions in pace with declining free allocation budgets or whether at some point they will be exposed to increasing carbon costs and hence leakage risk. This challenge will be exacerbated in cases where the rules determining free allowance allocation threaten to distort deep decarbonization in these sectors.

Addressing this concern will depend largely on where abatement opportunities lie for different industrial sectors and whether the allowance price will trigger the necessary reductions. Based on the analysis of this chapter, if significant abatement potential exists from fuel-switching and efficiency improvements in the production process, then benchmark-based leakage protection measures will continue to drive emission reductions so long as benchmarks are set appropriately. If, however, the majority of abatement potential lies in innovation in production processes and a demand response to increased product prices of carbon-intensive materials, there is a large risk that the basic materials sectors will not be equipped to reduce their emissions sufficiently under current policy settings. This is largely due to the absence of carbon costs in the product price of materials, which creates two distinct problems. First, demand-side abatement is not triggered. Second, investments in abatement technologies that require incremental costs are funded not through selling low-carbon products but rather through selling surplus allocation. This may not be a credible long-term investment framework as it relies on demand for allowances from other sectors that are decarbonizing as well as a commitment from policymakers to maintain free allocation.

Two approaches have been considered to directly address these concerns. First, alternative approaches to carbon leakage assessment may limit the number of sectors receiving allowances freely, hence reducing distortions and preserving the budget for those that need it most. Second, additional approaches to provide leakage protection have been put forward both in the academic and policy debate. Relatedly, broader policy support may be required, in addition to carbon pricing, to assist industry with the low-carbon transition. These issues are discussed in the chapters that follow.

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[11] See appendix for a review of the carbon leakage literature.

Table 3.2: Comparison of free allocation approaches in terms of their ability to drive deep decarbonization

Approach to free allocation	Protection against carbon leakage	Low-carbon production			Low-carbon consumption	Political durability		
		Fuel-switching; efficiency improvements	**Innovation in production processes**	**Material substitution**	**Material efficiency**	**International acceptance**	**Ease of implementation**	**Other**
Pure grandparenting	Weak	Strong	Strong	Moderate	Moderate	High	Low cost, easy to implement	Windfall profits likely
Grandparenting with updating	Moderate	Moderate, with possible distortions	Weak	Moderate (will vary for sectors depending on ability to pass on costs)	Moderate (will vary for sectors depending on ability to pass on costs)	Medium, resistance to windfall profits	Low cost, easy to implement	Windfall profits less likely (depending on updating)
Fixed base-period benchmarking	Moderate (depends on emissions trends and updating provisions)	Strong, with possible distortions from updating provisions	Weak	Moderate (will vary for sectors depending on ability to pass on costs)	Moderate (will vary for sectors depending on ability to pass on costs)	High	Requires detailed data for benchmarks	Windfall profits less likely (depending on updating)
Output based benchmarking	Strong	Strong (reliant on stringent product-based benchmarks)	Weak	Weak	Weak	High	Requires detailed benchmarks & regular production data	Windfall profits unlikely; environmental integrity of cap threatened for systems with narrow scope or without counter measures (e.g. adjustment factors)

4 Assessing carbon leakage risk

In this section, we first outline how criteria to determine eligibility for leakage protection have been defined and operationalized in existing ETSs. We then assess experiences to date with these criteria as well as critique from academic literature and consider alternative options for selecting industries at risk of carbon leakage.

4.1 LEAKAGE RISK ASSESSMENT IN PRACTICE

In theory, leakage risk is determined by the extent to which a domestic policy drives up local operating costs and the foreign production response (Fowlie & Reguant, 2018). In practice, policymakers have focused on two related metrics (Dobson & Winter, 2018). The first is an emission (or energy) intensity metric, which is designed to capture the direct and indirect costs of carbon pricing and is measured by emissions per unit of output, revenue, value-added, or profit (PMR, 2016). It captures the *impact* that carbon pricing has on a firm or sector (PMR, 2015). The second is a trade-intensity metric that aims to capture the capacity of a regulated firm to pass through the costs of carbon pricing to customers without losing profit or market share to international[12] competitors. Trade intensity is often measured by the total volume of imports and exports of a product relative to imports and domestic production. Trade, or the potential to trade, is what allows competition between producers in different jurisdictions. Together, these metrics are referred to as EITE criteria. EITE criteria are combined in different ways to identify which sectors are at risk of carbon leakage and, in some cases, to assess what level of risk.[13] However, the precise methodology varies across each system (see Table 4.1).

To date, EITE criteria have resulted in a broad approach to leakage protection that has been difficult to ratchet back. For example, in the EU the application of EITE criteria resulted in virtually all industrial sectors qualifying for free allocation in Phase III: about 170 sectors representing more than 97% of total industrial emissions (European Commission, 2019). The EU ETS will grant free allocation to far fewer industrial sectors from 2021-2030, but those continuing to receive protection account for 94% of industrial emissions. Owing to legislation adopted in 2017, California extended 100% assistance factors to industrial sub-sectors to 2030, marking a reversal from the phase-down in assistance factors for low- and medium-leakage risk industrial sectors that was originally planned to begin in 2015.[14]

Independent analysts have argued these choices have not always stood on firm empirical ground that captures true vulnerability to loss of competitiveness (Fowlie & Reguant, 2016; Fowlie & Reguant, 2018; IEMAC, 2018). For instance, different sub-sectors within a sector as defined by statistical authorities receive the same treatment regardless of differences in their ability to pass through carbon costs, and trade-exposure metrics are an imperfect measure of cost pass-through ability (see section 4.2). Without providing additional detail, California's Independent Emissions Market Advisory Committee has stated that more could be done to "ensure production-based subsidies conferred to industry reflect true leakage risk" (IEMAC, 2018).

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[12] Sub-national jurisdictions with an ETS may also face competition from domestic competitors that do not face an equivalent carbon price.

[13] See Dobson and Winter (2018) for a comprehensive review of EITE criteria across carbon pricing jurisdictions.

[14] California envisioned using a tier-based approach to reduce assistance factors depending on overall leakage risk. The assistance factor reduction was originally scheduled for 2015, but the reduction was delayed by regulatory amendments until 2018. However, based on recent reforms mandated by legislation, California will maintain assistance factors at 100% of sector benchmarks until 2030 for all classifications. Total levels of free allocation will, however, decline based on declining cap adjustment factors.

Table 4.1: EITE criteria across key ETS jurisdictions

	Emission intensity	Trade exposure	Carbon leakage criteria
EU ETS (Phase III)	[carbon price[15]× (direct emissions × auctioning factor[16] + electricity consumption × electricity emission factor)]/ gross value added	(imports + exports)/ (imports + production)	Direct and indirect cost increase >30%; or non-EU trade intensity >30%; or direct and indirect cost increase >5% and trade intensity >10%.
EU ETS (Phase IV)	[direct emissions + (electricity consumption × electricity emission factor)]/gross value added	(imports + exports)/ (imports + production)	Trade exposure * emissions intensity > 0.2 then considered to be at risk of carbon leakage Trade exposure * emissions Intensity between 0.15 and 0.2, qualitatively assessed and may be considered at risk of carbon leakage. Criteria include abatement potential, market characteristics, and profit margins.
California	EI = tCO2e/million dollars of value added	(imports + exports)/ (shipments + imports)	Emissions-intensity tiers: High: >5,000 tCO_2e per million dollars of value added; Medium: 1,000–4,999 tCO_2e per million dollars of value added; Low: 100-999 tCO_2e per million dollars of value added; Very low: <100 tCO_2e per million dollars of value added. Trade-intensity tiers: High: >19%; Medium: 10–19%; Low: <10%. Both measures are combined to determine final leakage risk category of low, medium, or high.
Québec	EI = tCO2e/ million dollars of value added	(imports + exports)/ (imports + production)	Three tiers for both emissions intensity and trade exposure: weak, moderate, high. Before 2021, assistance factors for all EITE sectors set to 100%; from 2021-2023, assistance factors set to 90% (low risk), 95% (medium risk), and 100% (high risk).
New Zealand	EI = tCO2e/ million dollars of revenue	Trade exposure is qualitative and based on the existence of trans-oceanic trade of the good in question.	Two tiers: 1. Highly exposed: emissions intensity >1,600 tCO_2e per million New Zealand dollars of revenue and trade exposed 2. Moderately exposed if emissions intensity >800 tCO_2e per million New Zealand dollars of revenue and trade exposed.
Republic of Korea	Defined as additional production costs incurred by ETS compliance: annual avg. GHG emissions during base year x avg. market price of allowances during base year	Relative to the base year: (annual avg. exports + annual avg. imports)/(annual avg. sales + annual average imports)	Additional production costs >5% and trade intensity >10%; or additional production costs > 30%; or trade intensity > 30%

[15] Assumed carbon price of €30

[16] Auctioning factor represents the share of allowances the sectors would need to purchase if not on the carbon leakage list in order to cover their emissions stemming from activities eligible for free allocation.

4.2 ALTERNATIVE APPROACHES TO ASSESS CARBON LEAKAGE RISK

The experiences outlined in the previous section raise the question of whether carbon leakage risk assessment could be improved in a way that results in more targeted assistance. What follows is a review of alternative criteria for assessing leakage risk. While some would capture critical nuances that are not fully accounted for by emissions and trade intensity, the review finds that many alternatives present barriers to broad application. This underscores that existing criteria remain the most viable choice for balancing tradeoffs between accuracy, administrative complexity, and consistency.

From an empirical perspective, views are mixed on trade intensity as an indicator of leakage risk and the ability of firms to pass through costs. Fowlie et al. (2016) provide limited evidence from California manufacturing of the importance of trade intensity for carbon leakage risk, finding low trade intensity results in low risk for the international component of leakage risk, even for emissions-intensive firms.[17] Fischer and Fox (2018) provide empirical support that trade intensity is a reasonable proxy for leakage risk when combined with high emissions intensity. However, Sato et al. (2015), assessing United Kingdom (UK) and German firms, find that trade intensity is a poor measure of cost pass-through given within-sector heterogeneity.

From a theoretical perspective, the ability to pass through costs is affected not only by trade intensity, but also by: the market structure and number of firms competing within an industry; the size of the domestic market relative to the international market; the nature of production and capacity constraints; and the level of regulation, including the degree of state-ownership (Neuhoff & Ritz; 2019; CARB, 2010a; Parker & Boggett, 2008). Furthermore, in a Paris-constrained world, the degree of international trade is no longer the only relevant consideration; also important are the carbon pricing policies of a jurisdiction’s trade partners.

Cost pass-through estimates for EITE firms may also be indicative of the quality of these criteria in estimating leakage risk.[18] Assessing the literature to date, cost pass-through has been detected in some industries that are considered at risk of carbon leakage. This includes the refining industry (Alexeeva-Talebi, 2011; De Bruyn et al., 2010; Laing et al. 2014), the iron and steel industries (De Bruyn et al., 2010), and to a lesser extent glass and ceramic goods, which show greater heterogeneity in terms of pass-through rates (Alexeeva-Talebi, 2010; Oberndorfer et al., 2010). Alexeeva-Talebi (2010) found a pass-through rate of 10-40% across a range of industrial sectors in the first phase of the EU ETS depending on market structure and strategic considerations. However, Sartor (2017) found no significant evidence of cost pass-through for the steel and cement sectors in

[17] Another study (Gray et al., 2016) from a 2016 California leakage assessment complemented the work of Fowlie et al. (2016) by evaluating leakage risk to other states using energy intensity as a proxy for emissions intensity, finding substantial short-run impacts on output resulting from higher energy prices. Long-run impacts were smaller, though the authors urged caution in interpreting those results, given challenges with long-run estimation.

[18] Pass-through estimation is complex, as it requires detailed data on product prices and production costs as well as exogenous variation in input costs to assess whether changes in costs result in changes to prices (Neuhoff & Ritz, 2019). Some studies rely on analysis of changes to other costs rather than specific changes in the allowance price. As explained by Zachmann (2008), pass-through of domestic shocks to, for example, electricity prices, interest rates, or exchange rates should be indicative of potential to pass through carbon costs, where distortions are not in place from free allowance allocation.

Germany and the UK over the period 2015-2017 and only a very limited pass-through rate for the same sectors in France.[19]

This dated empirical evidence reveals that estimates vary across time, space, and industries. However, evidence of some level of pass-through for European industry suggests that applying a trade-share metric may not accurately capture a firm's ability to pass through costs and may therefore result in over-compensating some industries and indicate a need for additional indicators to assess carbon leakage risk. Based on an assessment of the literature, six additional criteria are important in carbon leakage risk assessment compared to EITE criteria used to date, including:

1. emissions intensity of competing firms;
2. carbon constraints in competing jurisdictions;
3. the availability and cost of abatement technologies;
4. market structure and the nature of competition;
5. price and trade elasticities; and
6. profit margins.

These are discussed below and summarized in Table 4.2.

4.2.1 Emissions intensity of competing firms

Vivid Economics (2014) and Fowlie and Reguant (2018) point out that a focus on domestic emissions intensity fails to capture the effect on global emissions if production were to shift offshore. From an emissions leakage perspective, policymakers would seek to understand the emissions intensities of foreign producers that will scale up production in response to changing domestic costs. If a sector's main competitors are highly efficient or even more efficient than domestic producers, offshoring of investment or loss of market share may not imply a net increase in global emissions. While production leakage may still occur to the detriment of domestic competitiveness, this would not entail emissions leakage.

However, accurate ex-ante estimation of foreign emissions intensities is challenging due to data availability. While sector-level averages are available in some regions, emissions intensities vary significantly with the level of foreign production (Lyubich et al., 2018). This implies that taking average emissions intensity may not correctly measure the emissions response from increased foreign production. Better data to understand foreign emissions intensities should be a priority, as it could help refine jurisdiction-specific understanding of leakage risk.

4.2.2 Carbon constraints in competing jurisdictions

The ability to pass through costs will be affected by the diffusion of global carbon prices, which are expected to expand particularly in emerging economies as jurisdictions seek cost-effective implementation of their NDCs under the Paris Agreement. The inclusion of carbon pricing in emerging economies is significant for two reasons. First, carbon prices are more effective in reducing emissions in countries that are more energy and carbon-intensive, so the inclusion of carbon pricing in emerging economies might ease competitiveness concerns (Acworth et al. 2019; Vivid Economics, 2014). Second, emerging industrialized markets could be price-setters in global export markets, meaning that price pass-through in these jurisdictions could result in carbon

[19] A detailed summary of carbon cost pass-through literature is provided by Neuhoff and Ritz (2019).

costs being reflected in world trade prices. This is particularly relevant for China, which is planning the introduction of an ETS from 2020 that is intended to expand in coverage to include industrial sectors by 2025 (ICAP, 2020).[20] This suggests a need to update carbon leakage criteria as policy interventions to support emission reductions become more widespread around the world. Nonetheless, the allocation methodology of foreign competitors should also be taken into account: if everyone is using output-based mechanisms to address their own competitiveness issues, then no one is fully passing on carbon pricing onto those products.

4.2.3 The availability and cost of abatement technologies

Analysts have highlighted that the emissions-intensity metric does not consider an industry's ability to invest in technologies that reduce emissions from production or energy-related inputs. Firms that have higher potential to change their production processes or capital stock to reduce emissions at low cost will be in a better position to reduce their carbon costs and therefore their risk of carbon leakage.[21] From a practical perspective, assessing abatement potential may be challenging given wide-ranging differences between industrial sectors in terms of production processes, technological development, and other factors.

That said, abatement potential has and will continue to form part of the EU ETS second-level assessment for industries falling just below the threshold for emissions intensity and trade exposure. Metrics to assess abatement potential include:

- the emissions per unit of production that would be achievable using best available technologies;
- the share of installations in the sector or industrial activity using these technologies;
- the percentage reduction in emissions that would result from deploying the technology;
- the cost of utilizing this technology; and
- the impact its deployment would have on profit margins (European Commission, 2019).

4.2.4 Market structure and the nature of competition

One aspect that seems particularly relevant is the market structure and nature of competition that firms face. The number and concentration of firms in a market influence the ability of firms to pass through costs (Parker & Blodgett, 2008). For example, the more aggressively firms compete, the more they will take market share from one another when one has a cost advantage over another. Alternatively, firms in industries where only a few players compete may have bargaining power in export markets and hence a greater ability to pass through their costs and influence prices. In sum, the degree of competition between domestic and international firms is important for carbon leakage.

Antitrust authorities commonly apply different metrics to understand how aggressively firms compete when assessing mergers and acquisitions, cases of market abuse, or other anticompetitive behavior. Market

[20] However, it is difficult to assess what levels of price pass-through are likely for the Chinese industrial sectors given current information on system design.

[21] Anecdotal evidence of abatement potential might be gleaned through an assessment of the benchmark curves for industrial processes. If there is a large distribution of producers in terms of their emissions intensity this may indicate abatement potential at least for some producers. If, however, the distribution of emissions intensity between producers is small, this could imply producers are at the efficiency frontier and hence have few options to further reduce their emissions at given prices.

concentration is the commonly accepted measurement of competition, with low concentration indicating high levels of competition. Market concentration is commonly measured through two metrics:

1. **Herfindahl-Hirschman Index (HHI)** — calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers; or
2. **Concentration ratio** — calculated by summing the market share of the n largest companies (normally the four-to-eight-largest firms).

Using market structure as an indicator of leakage risk may run into challenges in the implementation, because the degree of potential cost pass-through in different market structures depends on the nature of demand in a market, and there is little empirical work estimating demand curves in practice (Arlinghaus, 2015). Indeed, cost pass-through could in fact be lower in oligopolistic or monopolistic markets where output is constrained and prices are already well above marginal cost. This challenge suggests market structure as an indicator of potential cost pass-through should be judged on a case-by-case basis (ibid).

Market tightness is another indicator of market structure with significant implications for cost pass-through (IEA, 2008). It refers to the level of spare production capacity outside of the regulated jurisdiction. Firms in a regulated jurisdiction could fully pass on their carbon costs if there is no spare foreign capacity to supply the market. Critically, market tightness hinges on commodity prices and business cycles (ibid). In a positive cycle, where demand exceeds supply, companies may succeed in passing through more of their cost increases than in a downward part of the cycle, when they may not be in a position to pass through costs without foreign capacity competing for market share. Evaluating market tightness would therefore require complex and differentiated measurements across sectors that require frequent adaptations to reflect the business cycle.

4.2.5 Price and import elasticities

The price sensitivity of consumers will determine how strongly they substitute away from a given product as the price rises. Consumers will be more responsive to price increases by any supplier when goods are more homogeneous and/or where there are viable substitutes. Consumers may be less responsive to goods that have a strong domestic brand or where substitutes are perceived to be of lower quality. Given that pass-through rates will be affected by the price sensitivity of consumers, some have argued that price sensitivity should feature in leakage risk analysis (PMR, 2015; CARB, 2010a; Parker & Blodgett, 2008). However, this would likely require estimating the shape and slope of product demand curves, which, as noted above, is challenging (Arlinghaus, 2015; Wooders et al., 2009; Parker & Blodgett, 2008).

Price elasticities may not, however, provide a complete picture, as they do not distinguish between the carbon intensity of substitute goods. Substitution towards low-carbon alternatives is precisely one desired effect of carbon pricing. What is to be avoided is substitution towards carbon-intensive foreign goods that are cheaper, as they do not incorporate carbon costs. Recognizing this, Fischer and Fox (2018) suggest a new measure of "import vulnerability" that reflects the scale of trade that will be displaced by domestic cost changes. The authors estimate "import vulnerability" at the NAICS-6 level, the same classification level that is typically used for leakage risk assessment. The authors demonstrate that import vulnerability is reasonably well correlated with trade intensity, supporting continued use of trade intensity combined with emissions intensity as a proxy for leakage risk. However, if discretion through a second-level assessment is used to consider less trade-exposed sectors for leakage assistance, import vulnerability could be applied to provide additional information on leakage risk (ibid).

4.2.6 Profit margins

Low profit margins could indicate a constrained ability to pass on additional costs to consumers or to absorb additional carbon costs from existing revenues, thereby forcing firms to shut down or to relocate. Profitability can also provide information on the aggressiveness of competition within a sector or market. The European Commission considers profit margins a potential indicator of long-term investment or relocation decisions in response to changes in the cost of production stemming from its ETS (European Commission, 2019). However, there is potential for profit margins to be an unreliable indicator, such as instances where a firm has adjusted its profit margins to minimize taxes or for other strategic calculations.

Table 4.2: Summary of alternative criteria to assess carbon leakage risk

Carbon leakage risk factor	Rationale	Potential metric(s)	Challenges in application
Carbon intensity of foreign production	• Important for understanding how emissions change when output shifts offshore	• Emissions intensity of competitors	• Difficult to access data • Competitiveness likely to continue to be a concern for policymakers
Carbon constraints of competitors	• Carbon leakage driven by cost differentials • Implicit and explicit carbon costs can be expected to grow with NDC implementation and commitments to net zero	• Average carbon cost faced by competing firms	• Carbon costs affected by leakage mitigation measures in competing jurisdictions that may be difficult to observe given carbon leakage provisions • Allowance price fluctuations • Impact on competitiveness of third jurisdictions that compete in export markets but do not price carbon

Abatement potential and cost	• The availability and cost of abatement technologies	• Best available technologies (BAT)
		• Market penetration
		• Reduction potential if BAT were applied
		• Cost of utilizing this technology
		• Profit margins
		• Impact of deployment on profit
			• Lack of empirical evidence upon which metrics can be based
			• Leakage risk remains where:
			  • incremental costs increase with adoption of technology
			  • emissions reduced but not eliminated
			  • capital constraints that create a barrier to tech. deployment.
			  • time dimension with regards to investment and innovation
			  • practical challenges for heterogeneous sectors

Nature of competition	• Competitive nature of the relevant market will influence ability to pass through carbon costs	• Concentration ratio or Herfindahl-Hirschman Index (HHI) • Diversion ratio • Profit margins • Market tightness	• Profit volatility and tax interactions can render assessments of market structure difficult • Changes at different levels of industry disaggregation and location, making broad application difficult
Price and import elasticities	• Price sensitivity of consumers has a strong relationship with the ability to pass on costs • Import elasticities reflect substitution towards foreign products	• Price elasticity of demand • Trade elasticity • Import vulnerability	• Estimating the shape and slope of a sector's demand curve is challenging • The metric will evolve with new products, branding, and consumption trends
Profit Margins	• Indication of attractiveness of investment in jurisdiction • Could reflect ability to pass through costs or absorb carbon costs	• Profit	• Year-to-year variability • Issues surrounding firm strategy in terms of depreciation and tax avoidance

4.3 IMPLICATIONS FOR CABON LEAKAGE AND DEEP DECARBONIZATION

EITE criteria have performed reasonably well in assessing leakage risk while balancing the trade-off between accuracy and administrative complexity. That said, across most systems, this has resulted in a rather broad application of leakage protection provisions which, at times, may have contributed to overallocation and windfall profits (Carbon Market Watch, 2015; Goulder et al., 2010; Sandbag, 2017). This may be appropriate in the initial phases of an ETS, where governments might seek to also compensate firms for existing assets to ease the transition into an ETS. However, as systems evolve to reflect net-zero trajectories, it is likely that the carbon leakage risk assessment criteria will need to be reviewed to ensure only those industries truly at risk qualify for leakage protection. This is pertinent both from a carbon efficiency perspective, but also in the context of prudent allocation of scarce government resources – allowances not awarded freely can be sold by governments, generating revenues that can be used for further climate action or attainment of other policy goals.

That said, a detailed assessment of the literature reveals no clear choice of additional metrics or tests that could be applied alongside existing EITE criteria to improve broad leakage risk assessment. The additional tests discussed above all come with caveats that would increase the complexity of leakage risk assessment, require significant additional data, and, at times, reduce the transparency of the approach. Furthermore, the provision of additional tests may also open alternative grounds for industry to inappropriately claim leakage risk, as they could choose from the most advantageous indicators.

One possible approach could be to lift the thresholds for qualification under EITE criteria such that only those deemed at "high" risk qualify automatically. A more complex assessment with a wider range of criteria could then be applied to sectors at lower risk levels. This would essentially be a slightly modified version of the EU's system of leakage risk assessment. The benefits of such an approach would need to be considered against the costs in terms of increased administrative complexity and reduced transparency. Another way to work with existing criteria would be to continue exclusively using emissions and trade intensity criteria but assigning different thresholds to different tiers (e.g. low, medium, and high) and giving each tier different levels of free allocation. California and Québec use such a tier-based approach, but both apply 100% assistance factors to all EITE entities at the benchmark level regardless of risk classification, though Québec will start differentiating assistance factors between 90-100% based on risk classification starting 2021. In California, 100% assistance factors are required through 2030 by legislation. Total levels of free allocation in California and Québec will, however, continue to decline based on declining cap adjustment factors.

If additional tests were to be applied, a focus on the nature of competition, import vulnerability, the carbon intensity of foreign production, as well as climate policy and leakage measures in other jurisdictions seem most warranted. The barriers to such analysis could be reduced by enhanced cooperation between governments.

5 Alternative approaches to address carbon leakage

In this chapter we consider alternative approaches to free allocation that offer a potentially wide scope of applicability and broad protections against carbon leakage for industrial sectors (see Table 5.2 for a summary). While these alternatives would incentivize abatement by both producers and consumers, additional supplementary policies are also likely needed to propel deep decarbonization across the economy. These are explored in chapter six. The policies explored here aim to address leakage through the output (short-term competitiveness) and investment (long-term competitiveness) channels outlined in chapter two. This is not to diminish the importance of leakage through the energy channel, which is often found to be the most persistent and intractable source of leakage (Zachmann & McWilliams, 2020). But leakage through the energy-markets channel lacks immediate policy tools to address the challenge and requires further attention.

5.1 BORDER CARBON ADJUSTMENTS

Border carbon adjustments (BCAs) apply tariffs or other measures to imported goods from countries that do not have comparable emissions pricing requirements for their emissions-intensive goods. BCAs may also include rebates or exemptions for domestic producers when exporting to markets without comparable emissions pricing. By leveling carbon costs on embodied emissions, a BCA aims to avoid carbon leakage from vulnerable sectors while strengthening incentives for abatement across industrial value chains, both domestically and abroad.

Extensively studied but never implemented for EITE sectors, BCAs are experiencing an upswing in political attention, particularly in Europe. Growing near-term heterogeneity in climate policy, greater availability and quality of emissions data, the ratification of the Paris Agreement, and setbacks in trade liberalization have opened a window of opportunity to seriously consider BCAs as an alternative approach to free allocation for addressing carbon leakage (Mehling et al., 2019). As part of the European Green Deal, the European Commission has stated that it will propose a BCA for selected sectors “should differences in levels of ambition worldwide persist” (European Commission, 2019b), which is a likely prospect.

However, designing and implementing a BCA is complex and politically challenging. It requires careful consideration of design features ranging from scope of coverage to the selection of benchmarks to determine the levels of adjustment, as well as risks of legal challenges based on World Trade Organization (WTO) rules. Ensuring an administratively feasible and legally robust design may present a trade-off relative to the BCA’s effectiveness against carbon leakage and in driving decarbonization.

5.1.1 Design considerations

In this section we analyze some of the key BCA design considerations.[22] Pragmatic design ultimately hinges on the sector or sectors covered by the BCA and in balancing trade-offs between the scheme’s effectiveness against carbon leakage, administrative complexity, and risks of WTO non-compliance or diplomatic backlash. While there is no certainty on legal compliance, particularly because there is no case law on BCAs, there is extensive analysis on how to design a scheme that maximizes its chances of legal durability (see Mehling et al.

[22] A more comprehensive view is provided by, for example Mehling et al. (2017), Carbon Trust (2010), Cosbey et al. (2012), Mehling et al. (2019), and Cosbey et al. (2019).

(2019) and Cosbey et al. (2019) for a thorough and recent view). There may be paths to a WTO-compatible BCA through the WTO General Agreement on Tariffs and Trade (GATT), which requires equal treatment of "like" goods, or through Article XX, which grants exceptions to GATT obligations based on environmental protection and other grounds.

The key design choices facing any jurisdiction considering a BCA include:

- **Scope** — products included in the scheme and whether it applies to imports, exports, or both;
- **Emissions coverage** — whether the scheme applies only to direct emissions from the production process or indirect emissions from energy-related inputs as well;
- **Determination of embedded carbon** — calculating emissions embedded in products on a facility-by-facility basis with actual data or using standardized benchmarks; and
- **Compliance instrument and level of adjustment** — the method of compliance (e.g. purchasing allowances) and determining the level of the adjustment (e.g. accounting for foreign carbon costs).

5.1.1.1 Scope of the BCA

To reduce administrative burdens while still delivering an environmental benefit, which may be integral to withstanding WTO challenges, analysts widely suggest focusing a BCA on products from sectors that are the most vulnerable to carbon leakage. While a wider scope would help underscore the environmental benefit of the BCA and thereby support its legality under an environmental exception to WTO obligations, it may increase political and administrative challenges. Legally, the BCA could not be broader in sectoral scope than what is covered under the domestic carbon pricing system. Sectors often highlighted as priorities for BCA coverage include steel, cement, and aluminum (Mehling et al., 2017; Cosbey et al., 2012; Carbon Trust, 2010). Additionally, coverage of electricity imports in a future BCA has been discussed by EU officials in response to increases in cross-border power generation. Choosing sectors where products and production processes are relatively homogenous also reduces administrative and legal challenges (Carbon Trust, 2010).

Focusing on a narrow subset of EITE sectors was the approach taken by the French in a 2019 BCA proposal, which would begin with steel and cement then possibly expand to aluminum and refining (see Box 5.1). An earlier French proposal in 2016, which received some support in the European Parliament, would have started even more gradually, beginning with industrial sectors of lower trade intensity, such as cement (Mehling et al., 2019). The proposal focused on sectors of lower trade impact but high emissions intensity to help contain international opposition while covering significant portions of industrial emissions.

The determination of sectors should include analysis of impacts on manufacturers farther downstream and potential substitution effects, among other areas of ex-ante impact assessment. For many products the effect will be negligible, but implementing jurisdictions should determine which downstream products would be affected, their potential additional costs, and to what extent they are exported in large volumes abroad, among other factors (Monjon & Quirion, 2010). There may also be substitution effects farther downstream if materials that serve as close substitutes and are both prone to leakage are not included in the scheme. This case may be relevant, for example, in relation to cement and steel in the construction sector. Failure to consider these factors could undermine the purpose of a BCA as consumers switch to the product(s) not covered by the BCA, and it could also lead to opposition within the covered sector(s).

Box 5.1: French proposal on BCA for the EU ETS (2019)

> The French Ministry of Economy and Finance presented an initial proposal on the design of a BCA for the EU ETS at COP25 in Madrid. The proposal would limit the sectors in the scheme at first to steel and cement, which account for 39% of emissions among EITE sectors, with the possible future inclusion of aluminum and refining. Importers would be required to surrender special, fixed-price allowances sold outside of the EU ETS but corresponding to the previous day's EUA price to avoid disrupting the wider market. The benchmark would be set at the average carbon intensity of EU producers, but the proposal allows for the possibility of a more stringent level or the world average for the product.
>
> Free allocation would be gradually phased out, with a transition period in which the BCA would be lowered to reflect free allowances received by EU producers. To account for impacts to downstream producers and EU exporters, the proposal includes an option for continued free allocation up to the proportion of export for each EU industry based on EU benchmark levels. Lastly, the proposal includes a one-year testing phase during which importers would be required to obtain and surrender allowances but at no cost.

Implementing jurisdictions will also need to determine whether the scheme adjusts only for overseas imports, domestic exports, or both (a full BCA). The leakage protections of a full BCA will vary sector by sector, depending on characteristics such as the degree to which domestic producers export to destinations where competitors do not face carbon costs (Fischer & Fox, 2012). However, there are numerous reasons to restrict the BCA to overseas imports. First, domestic export rebates may dampen abatement incentives in more export-oriented industries by continuing to shield a share of domestic production from carbon costs (Mehling et al., 2017; Mehling et al., 2019), though well-designed benchmarks to determine rebates could help maintain some incentives.[23] Secondly, export rebates pose greater legal uncertainty, raising potential challenges under both the WTO Agreement on Subsidies and Countervailing Measures and Article XX of GATT (Cosbey et al., 2019; Mehling et al., 2019).[24] Using rebates tied to an allowance price rather than exemptions could lead to situations where allowance price fluctuations risk overcompensation to domestic exporters that would render the rebates an illegal subsidy, as well as considerable administrative complexity (Mehling et al., 2019). Export rebates also put the legality of the entire BCA in jeopardy by conflicting with its rationale of reducing emissions, which may prove critical to achieving WTO legitimacy as an environmental exception to GATT.[25] Any exemption for domestic exports would need to be based on a sector-wide benchmark to help preserve abatement incentives, with similar trade-offs at play as benchmarks for import adjustments (Cosbey et al., 2012).

Empirical evidence shows that most of the leakage protections offered by a BCA can be secured through an imports-only system, but this may not hold for sectors in the implementing jurisdiction that are major net exporters (ibid). This issue underscores the need for implementing jurisdictions to analyze trade flows of sectors under consideration for a BCA and suggests different models of import and/or export coverage may be appropriate depending on the sector. The option of a BCA that only rebates domestic exports or exempts those producers from obligations to surrender allowances has not been widely studied but would be possible. In

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[23] A related distortion would arise in the case that an implementing jurisdiction has multiple benchmarks for a single product depending on the production process, because export rebates would encourage producers to export products made under more emission-intensive processes while selling the more efficient one domestically (Cosbey et al., 2012).
24 Cosbey et al. (2019) and Mehling et al. (2019) have somewhat contrasting bases for their views on the legality of export rebates, but neither advises the inclusion of export rebates.
[25] While Trachtman (2016) acknowledges the potential to undermine the BCA's environmental rationale, he does see feasible routes to including a form of export rebate, though his analysis focuses on border taxes, not specifically in an ETS context.

combination with adjustments for overseas imports, export rebates would be more likely to raise challenges from trade partners as an effort to favor domestic producers, but exempting products destined for markets that do not pose similar regulatory burdens is already a common practice, as with value-added taxes. Overseas importers would remain unaffected under an exports-only adjustment and would be treated the same as domestic products bound for markets abroad. Such an approach, however, would present drawbacks: sectors that heavily compete with overseas importers for domestic market share would remain vulnerable to leakage, and it would potentially incentivize more emissions-intensive production for exports in the implementing jurisdiction. Still, it could provide strong leakage protections for more export-oriented sectors.

5.1.1.2 Emissions coverage of the BCA

In addition to the scope of the adjustment, implementing jurisdictions need to determine whether the BCA applies only to direct emissions from production or also to indirect emissions from energy inputs generated off-site. For this analysis we exclude indirect emissions from sources other than energy inputs (i.e. scope three emissions), such as transport, because of methodological and data issues that make them infeasible for a BCA (Cosbey et al., 2012). Because indirect emissions from energy use constitute a large share of emissions for key industries such as aluminum, there is a strong rationale for covering them in a BCA that includes such industries (ibid). Additionally, in many industries indirect emissions present the greatest scope for regional variation (ibid). Any implementing jurisdiction that requires covered entities to surrender allowances for indirect emissions would likely also include them in its border adjustment.

Views on the legality and method of inclusion for indirect emissions vary somewhat. Including indirect emissions in a BCA implemented by a jurisdiction that does not explicitly cover them through surrender obligations risks WTO non-compliance based on WTO rules against non-discrimination as favorable treatment to domestic producers (Carbon Trust, 2010). Both Mehling et al. (2017, 2019) and Cosbey et al. (2019) argue that indirect emissions should be included if there is a carbon constraint on the production of these emissions in the implementing jurisdiction. Alternatively, the BCA could apply different emissions coverages for different sectors.

5.1.1.3 Determination of embedded carbon

Ideally the level of adjustment would be grounded in actual carbon content embodied in direct and indirect emissions at the facility level to most accurately reflect the emissions intensity of production and incentivize abatement (Kortum & Weisbach, 2017). If the adjustment is based on actual emissions, the abatement incentive is directly tied to lowering the cost of the adjustment their goods will face. This could be implemented by requiring overseas importers to submit emissions data verified by third parties in order to sell their goods in the jurisdiction implementing a BCA. However, this may prove both impractical and legally contentious, requiring implementing jurisdictions to instead establish default benchmarks to estimate the carbon content of imported goods and hence determine the adjustment (ibid). A deviation from the benchmark could be offered when in conjunction with third-party verified data demonstrating that the importer's actual emissions intensity is lower than the benchmark. Such an option could improve the efficiency of the BCA (giving some foreign producers incentives to reduce their emissions), alleviate administrative burdens (by not requiring burdensome certification in all cases), and improve legal compatibility (Cosbey et al. 2019).

Some authors have suggested multiple benchmarks for direct emissions might be needed to reflect different production technologies or processes (Mehling et al. 2019 and Cosbey et al. 2019). Importantly, the "one product, one benchmark" principle outlined in chapter three applies to rebates, where multiple benchmarks for similar products dilute abatement incentives by introducing distortions. However, for imports, multiple benchmarks that improve the accuracy of the carbon content estimate for the specific product may improve the efficiency of the price signal. Thus, there can be a tension introduced if both imports and exports are intended to be covered by border adjustments. Jurisdictions would need to weigh potential distortions and WTO implications of multiple benchmarks for the same product against the benefits of more granularity where the emissions intensity of production processes differs significantly.

Cosbey et al. (2019) suggest using country-specific default benchmarks for indirect emissions, given the availability of data from required reporting, while Mehling et al. (2017, 2019) argue that links to country-specific factors would make the proposal more risky from a legal standpoint and argue instead for using average regional grid emission factors as benchmarks. Cosbey et al. (2019) argue that more accurate, differentiated benchmarks could be supported by relying on a GATT exception based on environmental grounds. However, it is noteworthy that the rules for such exceptions still include provisions against discriminatory practices.

Table 5.1 summarizes the strengths and drawbacks of various options for benchmarks that have been suggested in the academic literature, drawing largely from Cosbey et al. (2012, 2019) and Mehling et al. (2017, 2019). The table speaks in general terms, as the effectiveness of benchmarks will vary by sector of the implementing country and the country of origin of that sector's major competitors. Ultimately the choice of benchmark presents a trade-off: the more closely they capture the emissions intensity of foreign production the better they incentivize efficiency and provide stronger leakage protections because of higher assumed emissions intensity, but they pose considerable administrative complexity and greater risks of WTO non-compliance. To date, however, the effectiveness of benchmark choices is an underdeveloped area of the economics literature on BCA.

Table 5.1: Options for benchmarks under BCA

Benchmark	Leakage protection	Ease of administration	WTO compliance
Direct emissions benchmarks			
Emissions intensity from worst practice in exporting country	Generally most effective (assuming high GHG intensity in many exporting countries)	Challenging: requires reliable data from all exporting countries and provisions to prevent export via third countries	Likely conflicts with GATT but could be granted under Article XX exception
Average emissions intensity in exporting country	Effective (though above-average producers have little incentive to improve and can still gain market share)	Challenging: requires reliable data from all exporters and provisions to prevent export via third countries	Likely conflicts with GATT but could be granted under Article XX exception
Global average sectoral emissions	Likely stronger in general than benchmark based on implementing country but less effective than one based on exporting country	Likely more challenging than benchmark based on implementing country (potentially harder to obtain comprehensive, reliable data)	Could be more likely to draw complaints than avg. emissions intensity in implementing country, as more exporters are likely to perform above it
Emissions intensity from worst practice in implementing country	Likely less effective in general than if based on exporting country (lower assumed GHG intensity)	More straightforward than for benchmark based on exporter practices	Likely compliant with GATT (all exporting countries face same benchmark)
Average emissions intensity in implementing country	Generally less effective than average based on exporting country (assuming lower GHG intensity in implementing country)	Straightforward option to implement (single benchmark with available data)	Likely compliant with GATT (all exporting countries face same benchmark)
Emissions intensity from best available technology in implementing country	Generally least effective option (lowest assumed GHG intensity)	Straightforward option to implement (single benchmark with available data)	Likely compliant with GATT (all exporting countries face same benchmark)
Hybrid (direct and indirect emissions) benchmarks			
Hybrid 1 (implementing country benchmark for direct emissions and exporting country benchmark for indirect emissions)	Fairly strong because indirect emissions often present wide regional variation and less costly mitigation options	Better than pure exporter-based benchmark on direct emissions because of better data availability for indirect emissions	Likely conflicts with GATT but could be granted under Article XX exception and likely seen as less punitive than pure exporter-based benchmarking
Hybrid 2 (global average sectoral emissions and average regional electricity grid emissions factors for indirect emissions)	Potentially as effective as Hybrid 1, depending on sector and implementing country; more effective than benchmark on direct emissions alone	More challenging than single benchmark for direct emissions based on implementing country; more research needed to determine whether this approach would be simpler than Hybrid 1	More likely to be GATT compliant than Hybrid 1 because it avoids country-specific links

5.1.1.4 Compliance instrument and level of adjustment

The implementing jurisdiction will need to decide whether the adjustment takes the form of a tax/duty or to require overseas exporters to purchase allowances (or other units) in proportion to the weight and carbon content of their goods. To ensure the BCA is legally sound, the instrument and price should adhere as closely as possible to obligations of producers in the implementing jurisdiction (Cosbey et al., 2019). For an ETS jurisdiction, compliance obligations would therefore involve surrendering allowances, paying a tax/duty that aligns with the market price, or purchasing international offsets up to the rate of adjustment (ibid).

If there is a requirement to purchase allowances, the implementing ETS jurisdiction will further need to decide whether these are sourced from within the cap or through a parallel system of single-purpose, non-tradable allowances. An option for the latter would be establishing special fixed-price allowances for BCA compliance that are tied to the spot allowance price but are not tradable within the wider market. Such an approach was suggested by France in a 2019 BCA proposal for the EU ETS (see Box 5.1).

Using allowances sourced from within the cap would help the implementing jurisdiction to ensure equal price obligations for domestic producers and overseas exporters and would potentially reduce emissions produced globally but consumed in the implementing jurisdiction (Sandbag, 2019). However, without a change in the cap, it would also push up prices for allowances, particularly as the cap declines, which may be undesirable for some implementing jurisdictions.

To accord with WTO rules, the level of the adjustment would need to account for any exemptions, rebates, or free allocation offered to domestic producers, as well as carbon pricing that overseas exporters already face in their country of origin (Mehling et al., 2019). Implementing jurisdictions could also consider exempting all overseas exporters from certain countries based on factors such as the ambition of climate policy in the country of origin or the country's level of development (e.g. least-developed countries), but this raises further complications as potentially discriminatory under WTO rules (Cosbey et al., 2012; Cosbey et al., 2019).[26]

5.1.2 Protection against carbon leakage

There is wide academic support for the effectiveness of BCAs to address carbon leakage through the competitiveness channel. Leakage through the energy-market channel, however, could remain. Böhringer et al. (2012a) find that BCAs are more effective than exemptions and OBA in addressing carbon leakage and minimizing the adverse effects of carbon pricing on EITE sectors' output. Summarizing 12 general-equilibrium models, Böhringer et al. (2012b) find significant reductions in carbon-leakage rates from BCA, and a meta-analysis of 35 *ex ante* studies by Branger and Quirion (2014) finds similar reductions resulting from BCAs. However, the benefits will vary based on the characteristics of the sectors included in the BCA and the design of the scheme. As previously highlighted, design choices are likely to entail trade-offs between effectiveness, legality, and ease of implementation.

Taking the example of EU steel, Dröge et al. (2009) find a full BCA (imports and exports) applied to both direct and indirect emissions would lead to a leakage rate[27] of -25.5%, meaning emissions reductions would occur in

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[26] Cosbey et al. (2012, 2019) identify a number of exemption types implementing jurisdictions could consider, including for least-developed and low-income countries, but generally advise caution.

[27] Leakage rates refer to the portion of a jurisdiction's emissions reductions that result in increased emissions abroad, with a positive number indicating leakage and a negative number indicating a net decrease in total emissions in both the jurisdiction and abroad.

both the implementing jurisdiction and among importing countries. A narrower BCA covering only imports and direct emissions leads to a leakage rate of 9.3%, meaning there would still be small emissions increases among countries facing the BCA — significantly better than no border levelling (38.9%), but far less impactful than the comprehensive approach.

The benchmark levels in the BCA also play a critical role in leakage protections. Continuing from the example above of EU steel, using a benchmark of average emissions intensity of EU steel producers, rather than basing the adjustment on actual emissions, would reduce the effectiveness of a full BCA for EU steel from -25.5% cited above to -4.1% (ibid). To further highlight limitations, using emissions intensity from the best available technology (BAT) as a benchmark may require no foreign data and would be among the most legally robust ways to determine the adjustment but would generally be the least effective at preventing leakage or incentivizing cleaner production in exporting countries (Cosbey et al., 2012). Such a benchmark would severely limit the scope of emissions covered under a BCA and the adjustments faced by major overseas exporters with carbon-intensive production such as China, undermining the rationale for BCA (Sakai and Barrett, 2016). Studies suggest that benchmarks based on average emissions intensity or practices of producers in the exporting country are generally more effective than benchmarks based on the country implementing the BCA because of likely higher GHG intensity (Cosbey et al., 2012; Cosbey et al., 2019), though this depends on the key trading partners for a sector and the emissions intensity of the industry in the implementing country relative to major competitors.

Resource shuffling and trade distortions may also pose challenges to the effectiveness of a BCA against carbon leakage. Resource shuffling refers to efforts to shift lower-carbon exports of goods covered by the BCA to the implementing jurisdiction while consuming the more emissions-intensive materials domestically or re-routing them to markets without border adjustments. This would undermine leakage mitigation globally. However, there is little modeling to date to give a sense of the potential magnitude of the risk. Secondly, there could be distortions farther down the value chain from the products covered under the BCA. Tariffs between the US and China on steel and aluminum introduced in 2018 have led to increased Chinese imports of intermediate products containing those materials, hurting US demand for domestic production and prompting extension of tariffs farther down the value chain (Zachmann & McWilliams, 2020). However, there is little modeling on the potential magnitude of this risk for BCAs. A weaker BCA that imposes fairly low adjustments would be less prone to introduce such trade distortions but would instead raise questions about its effectiveness against leakage.

5.1.3 Compatibility with long-term transition

BCA provides strong incentives for decarbonization because consumers across the value chain face prices that are more consistent with the carbon content of the goods and materials they are purchasing (Dröge, 2011). However, a full BCA that also includes rebates to exporters in the implementing country will lower export prices relative to an alternative without export rebates, weakening incentives for demand side emission reductions in sectors that benefit from the rebate (Mehling et al., 2017; Mehling et al., 2019).

In cases where BCAs are phased into a system that maintains some level of free allocation, the calculation of the BCA must recognize free allowances or other compensation afforded domestic industry and extend the same benefits to importing firms under WTO rules (Cosbey et. al, 2012). Continuing free allocation would imply a smaller level of adjustment through the BCA and would limit incentives to reduce emissions along the value chain, undermining the rationale for adopting alternative approaches to mitigating carbon leakage in the first place. Sakai and Barrett (2016), among others, argue BCAs combined with auctioning (i.e., no free industrial allowance allocation) for the affected sectors and activities is preferable to a hybrid of partial BCAs and free allowance allocation because the former allows for stronger price signals without creating distortions (see also Fischer & Fox, 2012).

With the addition of revenue from overseas exporters and greater auctioning of allowances, BCA also generates more funding to invest in low-carbon technological innovation relative to free allocation. However, implementing jurisdictions may face pressure to return some revenue generated from border adjustments to exporting countries as refunds or climate-oriented development assistance on equity grounds or as capacity-building to ease BCA compliance (Cosbey et al., 2012).

5.1.4 Political durability

While BCA offers advantages over existing leakage protection measures, it faces significant implementation challenges and other risks, the most notable of which is the prospect of diplomatic tension and compatibility with WTO rules. While a BCA scheme under an ETS can be designed to increase the likelihood that it could withstand a WTO challenge, there is no existing case law on which to judge legality because border adjustments on carbon-intensive goods have never been attempted. As noted earlier, design choices that enhance a BCA's legal prospects and administrative feasibility are likely to mean curtailing the BCA's capacity to address leakage concerns and maximize abatement incentives.

There are three avenues under which a BCA implemented specifically by an ETS jurisdiction has the best prospects for complying with international trade law (Mehling et al., 2019):

- adjusting for an internal tax or other internal charge under GATT Article III.2;
- adjusting for an internal regulation under GATT Article III.4; or
- as an exception to GATT on environmental grounds under GATT Article XX.

The first two routes falling within the GATT would require that the BCA follows WTO rules of non-discrimination, which require that imports are not charged more than "like" domestic products and that any advantages or exemptions granted to domestic products are also extended to imports. The third route of seeking an exception to GATT under Article XX on environmental grounds still includes language on non-discrimination in its introductory paragraph, along with other likely constraints based on WTO case law. Based on past disputes concerning the protection of natural resources, the jurisdiction implementing BCA will likely have to demonstrate that its scheme substantively addresses climate change (Cosbey et al., 2019).

These non-discrimination provisions imply numerous trade-offs for BCA design detailed in previous sections, without any guarantees that the scheme will be WTO-compliant in the event of a challenge. Determining the adjustment based on actual verified emissions data at the facility level would be the ideal scenario, but this may prove both impractical and legally contentious. Instead adopting benchmarks to determine the adjustment represents a next-best option. The choice of benchmark further entails trade-offs: using a single benchmark based on the implementing country's production would allow for streamlined enforcement that relies on more easily verifiable data, making application as simple as multiplying the weight of an imported good by the benchmark and the allowance price, but this would likely be less effective overall than benchmarks based on individual exporting countries. Avoiding rebates or exemptions for domestic exporters would also simplify implementation and improve legal prospects at the expense of stronger leakage protections for some sectors.

Even a well-designed BCA that could successfully navigate the trade-offs highlighted in this chapter might face resistance from industry. Potential reasons for opposition include familiarity with a system of free allocation that is perceived to have largely insulated industry from leakage, concerns that a BCA will not be strong enough to fully internalize carbon costs in the market, and the potential for exporters to game the system by directing lower-carbon shares of production to the implementing jurisdiction while sending more emissions-intensive materials to less constrained markets (Sandbag, 2019). Additional concerns may be the potential for trade retaliation, short-term competitiveness losses domestically from full auctioning, and competitiveness of exports from the implementing jurisdiction without rebates or exemptions. However, there is also likely a degree of recognition among the most vulnerable EITE sectors that free allocation will become increasingly scarce in many jurisdictions any ETS. Maintaining free allocation in the early stages of a BCA and gradually phasing it out as a transition period might therefore help overcome political opposition.

Concerns about equity and trade relations also need to be taken into account. Even a well-crafted BCA may prompt accusations of “green protectionism”, masking an attempt to limit imports from developing and emerging economies with environmental concerns (Mehling et al., 2019). This perception will likely sour trade relations and may provoke retaliatory measures. Evidence supports these concerns: studies suggest that BCAs shift the costs of emission reductions to poorer, non-abating countries, who will experience losses in their terms of trade (Böhringer et al., 2012c), exacerbating regional inequalities (Sakai and Barrett, 2016). Concerns about equity — both in terms of treatment of developing countries and fairness towards trading partners that have already enacted comparable constraints on emissions — would be especially relevant if an implementing jurisdiction pursues BCA through an environmental exception to GATT. Addressing these concerns by exempting some countries could, in turn, undermine the legality of the scheme by increasing the likelihood that it would be viewed as discriminatory or arbitrary (Cosbey et al., 2019; Mehling et al., 2019).

Finally, sub-national jurisdictions may face additional challenges in designing and implementing a BCA because of constraints in national law or the national constitution. For example, the Commerce Clause in the U.S. Constitution grants the U.S. Congress exclusive authority to regulate economic relations between states and with foreign nations. Fowlie (2017) has noted the potential for constitutional challenges if California adopted a BCA on goods, in addition to WTO risks. However, there are legal scholars who argue that California implementing a BCA could be legally robust under the U.S. Constitution if it applied consistent benchmarks and was motivated by environmental concerns (Gamage & Shanske, 2017). Regardless, there is at least the potential that sub-national jurisdictions would need to defend a BCA on multiple legal fronts.

The challenges outlined in this section suggest the need for a cautious, transparent, and deliberative approach to designing a BCA, with a limited number of sectors covered under the initial scheme. An ETS jurisdiction considering a BCA should engage both with the WTO for greater clarity on the legal dimensions and with trading partners in bi- or multi-lateral discussions on its plans before adoption. It may also be prudent to design a BCA that could qualify under the GATT or as an exception under Article XX (Mehling et al., 2017). Careful consideration should also go to which sectors in the implementing jurisdiction are best suited for BCA in terms of effectiveness against carbon leakage, given likely constraints on design as well as substitution effects, downstream impacts, and administrative feasibility.

5.2 CONSUMPTION CHARGES FOR CARBON-INTENSIVE GOODS

In broad terms, consumption charges aim to restore price signals on the use of emissions-intensive goods rather than their production. While BCAs aim to capture the cost of emissions in the production of goods, consumption charges aim to restore prices signals on the use of goods. Both mechanisms may ultimately take the form of a benchmark multiplied by the weight of material and an allowance price, but a key distinction is their respective point of application. Also known as a "Climate Contribution" or "Inclusion of Consumption", a consumption charge combined with OBA represents an alternative to BCA that would seek to maintain free allocation for EITE sectors under its scope for leakage protections while passing on costs not reflected in production farther down the industrial value chain through an additional charge. No jurisdiction has implemented consumption charges on carbon-intensive industrial materials, but consumption charges have been implemented on other emissions-intensive activities or products, such as fossil fuels and electricity generation.[28] Here we focus on consumption charges applied in a system of free allocation, where they would be designed to pass on carbon costs that are otherwise blunted through leakage provisions.

5.2.1 Design considerations

While consumption charges could be applied to all sectors deemed at risk of carbon leakage in the implementing jurisdiction, existing work focuses on application to basic materials that account for the largest shares of industrial emissions.[29]

Domestic firms that produce materials under the scope of the consumption charges would receive free allowances based on recent or actual levels of output and a product-specific benchmark (see Figure 5.1 for an illustration of the mechanism). This would be critical to avoid double charging and to maintain leakage protections. Without free allocation to producers, consumers would face consumption charges and would be more likely to face carbon costs passed on from producers in product prices. Neuhoff et al. (2016) and Ismer et al. (2016) suggest tying allocation to intensity benchmarks calculated according to the best available technology among domestic producers in the sector, which would avoid allegations of excess subsidies to domestic producers or excess carbon levies on imports. However, the implementing jurisdiction could choose another benchmark, such as average emissions intensity of domestic producers, which would likely provide stronger protections against leakage and higher subsequent charges on consumption of the materials covered under the system. As with BCAs, selecting a single benchmark for the product that can be uniformly applied rather than a multitude based on each exporting country may be necessary to ensure the charges are not deemed discriminatory by WTO.

A consumption charge would then be levied on the intermediate or final consumption of a product, regardless of whether it was produced domestically or imported. The charge would be based on the weight of the material; the product-specific benchmark used for allocation of free allowances; and the price of an allowance in the ETS, which could be updated annually or quarterly to minimize administrative burdens (Neuhoff et al., 2016). Using the same benchmark for free allocation to calculate the consumption charge would ensure the liability is proportional to the level of pricing that is not captured upstream because of free allocation.

Domestic firms from sectors covered by the scheme would have to report their production volumes and would

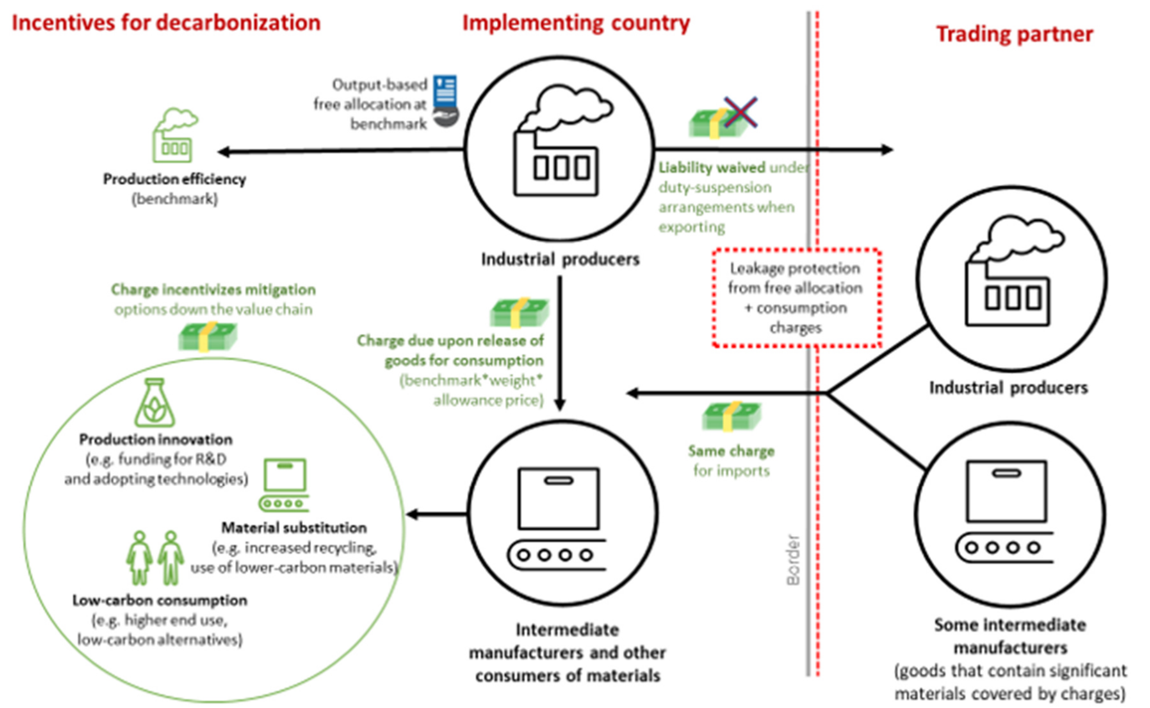
[28] See Munnings et al. (2016) and Raffaty and Grubb (2018) for an overview of other consumption charges.

[29] For a more detailed understanding see Neuhoff et al. (2016) and Ismer et al. (2016).

be held liable for the consumption charges due. Producers would either pay the charges themselves or reflect the charges in their pricing at the point of sale for intermediate consumption. Duty-suspension arrangements provide an option for qualifying firms to forego consumption charges if their materials or the subsequent product will be exported (see Ismer et al., 2016 for a more detailed look at this aspect of administration). Such relief for exports would comply with the destination principle of international trade, which holds that indirect taxes such as value-added tax and excise duties are levied on goods where they are ultimately consumed, irrespective of where the goods were produced (Ismer et al., 2016).

The liability for imported materials subject to consumption charges would be equivalent. Ensuring compliance would require integrating the liability for relevant product categories in the implementing jurisdiction's existing tariff system and establishing accounting and reporting systems that are not overly burdensome relative to obligations for domestic producers. However, limiting the scope to only basic materials would ignore the importation of carbon-intensive goods farther down the value chain and could fail to adequately address carbon leakage given that domestic consumption would be priced along the value chain (Ismer et al., 2016). This suggests that the scope should be extended to imports that contain high levels of materials covered by the consumption charges.

Figure 5.1: Illustration of consumption charges and incentives across the industrial value chain



Source: author's own illustration based on Neuhoff et al. (2016) and Ismer et al. (2016).

Implementing jurisdictions could limit the administrative burden by restricting charges to select product categories of the Harmonized Commodity Description and Coding System (HS). Pauliuk et al. (2016) suggest limiting charges to around 1,000 product categories, which would account for about 85% of emissions stemming from five major sectors of carbon-intensive materials. The level of administrative complexity would depend on the threshold of covered material a product may contain for inclusion in the system of consumption charges and data availability.

5.2.2 Protection against carbon leakage

Consumption charges that include output-based free allocation for producers of basic materials would provide strong protection against carbon leakage, at least in the near term. When tied to recent output, such a system best represents actual production levels and does not penalize growth, limiting firms' exposure to carbon costs that may put them at a competitive disadvantage. Producers would only have to purchase allowances for emissions that exceed the benchmark level. While there is limited modelling on consumption charges for basic materials, Pollitt et al. (2018) found that a scheme covering steel, cement, and aluminum to 2050 would not lead to carbon leakage. Böhringer et al. (2017) found that consumption charges paired with free allocation can lead to negative leakage, on par with or better than BCA depending on the rate of the charge. However, neither study incorporates assumptions on levels of free allocation and scenarios in which it declines.

The strength of consumption charges against carbon leakage would depend on future levels of free allocation. Many ETS jurisdictions envision steep declines in free allocation to 2030 as they pursue more ambitious reduction goals. This is only likely to accelerate to 2050. If this decline occurs alongside continued discrepancies in carbon pricing among key trading partners, domestic EITE sectors would face increasing carbon costs and thus leakage risks. Critically, this would depend on the extent to which EITE producers have decarbonized in step with declining free allocation. In the absence of sustained free allocation, jurisdictions implementing consumption charges may need to consider other means of industry compensation to fully guard against potential carbon leakage, make changes to the distribution of allowances to prioritize certain sectors, or transition to an instrument that levels differences in carbon costs among trading partners. Similar to a system of free allocation with benchmarks, there is also a chance of greater leakage exposure as benchmark stringency increases and allowance prices increase while large discrepancies in carbon prices worldwide remain.

Additionally, as stated in the previous section, leakage protections would also depend on the extension of consumption charges to imports that contain significant portions of covered materials. Otherwise, manufacturers farther down the value chain in the implementing jurisdiction could find themselves at a competitive disadvantage.

5.2.3 Compatibility with long-term transition

Consumption charges provide strong incentives for decarbonization. Levying consumption charges based on the carbon intensity of production restores price signals downstream that are otherwise suppressed under OBA alone, stimulating demand for low-carbon materials, more efficient use of industrial commodities, and other behavioral shifts that are needed to bring about a low-emissions, circular economy. Combined with ambitious benchmarks for allocation to production, consumption charges can also incentivize upstream efficiency (van de Lindt et al., 2017). In this way, the carbon price incentivizes the full suite of supply and demand side abatement potential that is required to unlock decarbonization.

Like BCA, consumption charges could provide significant revenue for low-carbon technological innovation and would likely need to be applied to climate-related investments rather than redistributed among domestic producers to support WTO compliance (Neuhoff et al., 2016). Such complementary support for technology would be necessary to drive investment in deep decarbonization (Åhman et al., 2017), especially considering limitations to upstream incentives (see chapter 6). A scheme applied to steel, aluminum, plastics, paper, and cement in the EU would generate an estimated €17 billion per year in revenue at an allowance price of €30 per ton of CO_2 (Pauliuk et al., 2016). Neuhoff et al. (2019) have also suggested redistributing a portion of the proceeds on a per-capita basis to the general public, which would make the policy more progressive assuming less consumption of affected products among lower-income households. The same per-capita redistribution could be considered for BCA proceeds as well.

Unlike BCAs, consumption charges are not aimed at levelling discrepancies in carbon pricing between trading partners. This, combined with continued reliance on free allocation, may limit their potential to incentivize abatement outside of the implementing jurisdiction. Trading partners would have little reason to phase out free allocation if they would face consumption charges for their exports to a jurisdiction implementing consumption charges on top of their own domestic carbon price.

5.2.4 Political durability

In the area of political durability, consumption charges offer some potential advantages over BCA but with some notable uncertainties. Perhaps most significantly, as an internal charge in which both domestic production and imports face the same liability without discrimination on the point of origin, consumption charges are less likely to face WTO challenges in some cases. This would be true for any model of a BCA that includes export relief for domestic producers, differentiates benchmarks based on the importer's country of origin, or uses multiple benchmarks for the same product to reflect different production processes or technologies. However, a less ambitious BCA that only covers imports with a benchmark based on the implementing country's producers would be similar in design to a consumption charge.

Secondly, administration may be simpler than BCA depending on the scope and design of the border adjustment. Consumption-based charges — and the infrastructure to collect them — are already well-established across much of the world and typically administered by customs officials, sometimes in coordination with other relevant government entities. Value-added taxes and excise duties on tobacco and alcohol are just a few examples that are commonplace. For at least some jurisdictions, levying charges on carbon-intensive consumption would be easier than levying consumption taxes and charges on other goods that require stricter controls from a monitoring standpoint (Ismer et al., 2016). For example, quarterly instead of transaction-based reporting could be sufficient for monitoring, and companies could rely on documents and processes that are already in place for business and tax purposes (Neuhoff et al., 2016). Similarly, duty-suspension arrangements could be handled within existing structures of monitoring and compliance.

However, the extension of consumption charges to imports farther down the value chain that contain significant portions of covered materials (discussed in section 5.2.1) would increase the administrative demands of the system, depending on factors such as inclusion thresholds and data availability. Ismer et al. (2016) argue this extension to intermediate and final imports would not pose risks of WTO non-compliance because these products would face the impacts of the consumption charge when domestically produced.

The need for robust and sustained free allocation for producers of industrial materials under consumption charges could present a political dilemma. Without this, domestic firms may be at risk of carbon leakage as declining budgets for free allocation expose them to greater carbon costs and a competitive disadvantage, but sustained levels of free allocation are likely incompatible with more ambitious reduction targets. As noted in section 5.2.2, vulnerability to leakage would depend on the extent to which EITE producers have decarbonized in step with declining free allocation. Implementing consumption charges may therefore require offering additional support to sectors at significant risk of leakage, shifting approaches to free allocation (e.g. establishing different tiers of recipients that receive different levels of allowances in order to conserve remaining budgets), or transitioning to an instrument that levels differences in carbon costs among trading partners. One way to compensate for allowance shortfalls would be to direct a portion of the revenue from consumption charges to domestic producers, but implementing jurisdictions would need to consider WTO rules when doing so.

The constraint on free allocation highlights the decarbonization challenge not only for consumption charges, but all policies aimed at reducing carbon leakage. Leakage protection is only intended as a short to medium-term measure to assist industry transition away from high-carbon products and processes towards those that will be competitive in a net-zero economy.

Lastly, cost pass-through to intermediate manufacturers will increase the price of basic materials, though the impact on final consumer goods may be generally negligible depending on the sectors subject to consumption charges. For instance, a charge of €30-50 per ton on steel and aluminum would increase the price of a car by an estimated €48-90 (Monjon & Quirion, 2010; Neuhoff et al., 2016). Pauliuk et al. (2016) find that a €30 carbon price with consumption charges on basic materials would increase prices on manufactured goods by less than 2% overall. Still, there could be a risk of public backlash where consumers feel unfairly treated and major industries continue to receive emissions allowances for free. As noted above, Neuhoff et al. (2019) suggest using a substantial portion of revenue from climate policies to reimburse the general public on a per-capita basis, as is done in Switzerland and parts of Canada to distribute carbon tax receipts.

Table 5.2: Comparison of BCA and consumption charges in terms of their ability to drive deep decarbonization

Alternative approach to leakage protection	Protection against carbon leakage	Low-carbon production		Low-carbon consumption		Political durability		
		Fuel-switching; efficiency improvements	Innovation in production processes	Material substitution	Material efficiency	International acceptance	Ease of implementation	Other
Border Carbon Adjustment (BCA)	Strong, depending on design, sector, and extent of resource shuffling/trade distortions	Strong	Strong (also source of revenue for low-carbon technologies)	Strong (assuming cost pass-through)	Strong	Low to medium (risks for WTO compliance and trade relations)	Moderate to very challenging, depending on design	Potential domestic opposition (e.g. industry itself); limits to incentives for trading partners to reduce emissions
Consumption charges	Strong with continued free allocation or other production support	Strong (assuming single product benchmarks)	Strong (also source of revenue for low-carbon technologies)	Strong (assuming supply-chain coverage)	Strong	Medium to high (easier path to WTO compliance than more ambitious BCA option)	Moderate (potentially easier than BCA depending on design/thresholds for inclusion)	Continued reliance on OBA; potential domestic opposition (e.g. industry and the general public)

6 Additional policies supporting decarbonization

Even with policies that restore price signals across the industrial value chain to incentivize emissions reductions on both the supply and demand side, deep decarbonization will require additional tools. For one, carbon prices are still far too low to make many carbon-neutral technologies for industrial production economically viable (Sartor & Bataille, 2019). Secondly, low-carbon investments for emissions-intensive industry face challenges of price uncertainty in carbon markets and high costs over long time spans. Lastly, the potential for investment offshoring that leads to leakage from a loss of long-term competitiveness underscores the need for additional policies targeting emissions-intensive industries.

This section explores some additional policies that could support deep decarbonization.

6.1 SUBSIDIES OR REBATES FOR LOW-CARBON TECHNOLOGIES

Technological changes to the production processes of emissions-intensive industry have historically come from improved economic performance or changes in consumer demand in response to regulations, but deep decarbonization requires long-term policies across the innovation chain, from basic research to support for deployment. This combination of technology-push and demand-pull measures targeting EITE sectors have been largely absent, which has resulted in an underdeveloped market for low-carbon technologies in production processes (Åhman et al., 2017). Consequently, subsidizing or rebating the deployment and supply of abatement technologies has emerged as a tool to both facilitate the low-carbon transition of emissions-intensive industry and reduce carbon leakage. This could be done either downstream to encourage the adoption of technologies or upstream to incentivize the suppliers of technologies, for instance by defraying manufacturing costs or subsidizing critical inputs such as research and development (R&D) (Fischer, 2016).

The market for low-carbon technologies in other sectors — particularly transport, buildings, and energy — is far more advanced than for heavy industry, owing to more concerted government policies spanning decades (Åhman et al., 2017; IEA, 2019b). Subsidies and rebates in these sectors have become commonplace. For example, at least 147 countries have policies directly supporting renewable energy, such as feed-in-tariffs, which has helped propel annual growth in capacity (IRENA et al., 2018). But heavy industry presents challenges with technology uptake: huge capital costs with long investment cycles and higher risks, among other factors (Åhman et al., 2017). Because these industries produce globally traded goods, support mechanisms are also more likely to face WTO challenges than more domestically oriented sectors.

Growing awareness of these challenges is leading to greater policy focus. For example, the EU ETS Innovation Fund will prioritize demonstration projects for industrial sectors for the first time starting 2021, and InvestEU envisions supporting successful projects from the Innovation Fund to scale up. Québec plans to combine reductions in free allocation with dedicated funding to support mitigation for EITE entities (ICAP, 2020), along with significant additional budgetary support for industrial decarbonization. The EU is also considering placing conditions on indirect cost compensation for Phase IV of the EU ETS that would require additional investment in low-carbon technologies and production processes to receive aid (European Commission, 2020).

There is also growing awareness — in large part thanks to the IPCC — that achieving climate neutrality requires negative emission technologies, such as bioenergy with CCS, to compensate for residual emissions from industry. Deploying such technologies at scale will require substantial public subsidies, in addition to other policies such as regulatory standards and reforms to carbon pricing (Bednar, et al., 2019; Bellamy, 2018; Fajardy et al., 2019). But precisely how to cost-effectively incentivize negative emission technologies, which technologies to prioritize, and the level of deployment that is likely needed are still underdeveloped areas of study (Bellamy, 2018; Fajardy et al., 2019).

Greater support is needed both for deployment of low-carbon technologies for industry and upstream to the firms developing and manufacturing those technologies. However, there is a stronger case for upstream subsidies from the standpoint of global welfare in that they tend to reduce global technology prices and emissions leakage through spillover effects (Fischer et al., 2014). They also provide domestic technology firms with a strategic advantage and shift a greater share of profits home (ibid). The nature of upstream markets further strengthens the rationale for targeting them for assistance: the technologies they produce are still relatively new to the market, the number of suppliers is small, and they are still developing economies of scale, all of which means they are not perfectly competitive and may justify government intervention (Fischer, 2016).

While many — if not all — WTO member countries use subsidies to advance public policy, such subsidies occupy a questionable legal status under the WTO Subsidies and Countervailing Measures Agreement (SCM Agreement). The SCM Agreement originally included a defined list of subsidies that are protected from challenges, including for R&D and environmental protection, but these provisions expired and WTO members have been unable to agree on reinstating them or drawing up a new list (Howse, 2010). Moreover, the legality of upstream subsidies is more uncertain because the SCM Agreement tends to hold subsidies to manufacturers as discriminatory (Fischer, 2016). By contrast, the WTO stated in 2011 that its rules do not forbid measures supporting the deployment of green technologies, meaning downstream subsidies are safer from a legal standpoint (Fischer, 2016). However, there is some WTO case law in favor of subsidies directed toward creating a new market, as distinguishable from one advantaging existing producers in established markets, which lends some support to upstream subsidies for technology (Cosbey & Mavroidis, 2014). Despite this legal uncertainty, support for R&D is rarely challenged under WTO, which suggests some upstream subsidies are likely safe to pursue (Fischer, 2016).

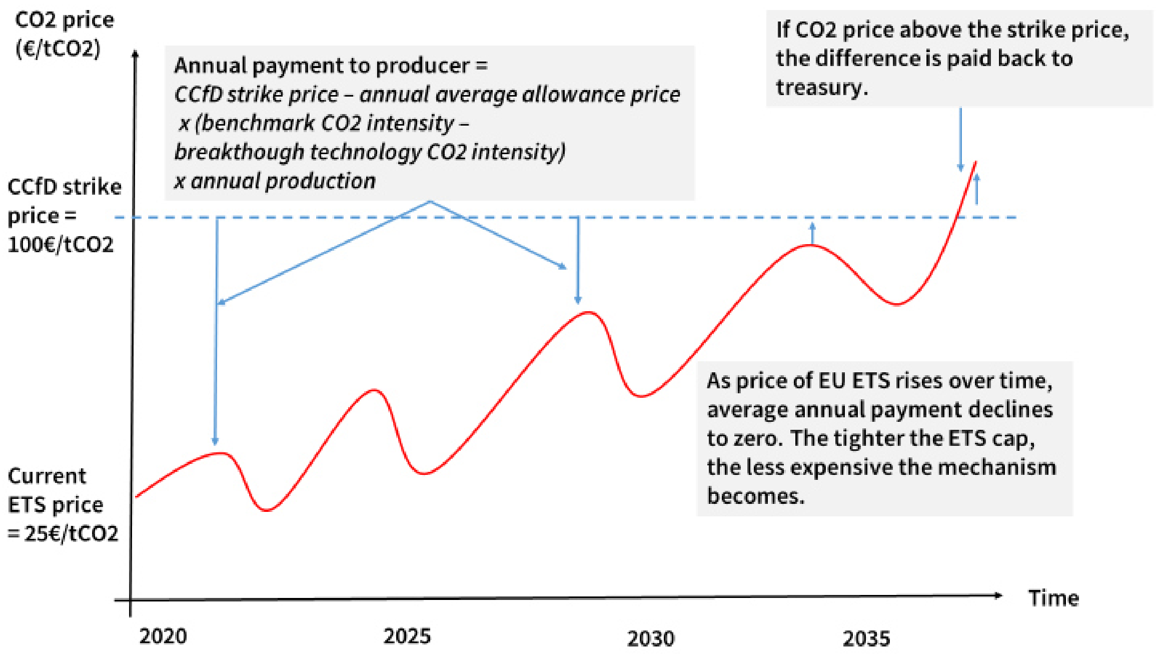
The extent to which technology subsidies could substitute for leakage protection through free allocation — and therefore justify reductions in allowances to EITE sectors — has not been fully addressed by academic research. Interventions to support the supply of and demand for low-carbon technologies have instead been considered sound complements to carbon pricing in the presence of additional market failures (Fischer et al., 2017). There is good evidence that optimal long-term policy combines carbon pricing with research subsidies (Acemoglu et al., 2012). BCA with auctioning or charges on the consumption of industrial materials could provide additional revenue to support low-carbon technologies for industry both upstream and downstream.

6.2 PROJECT-BASED CARBON CONTRACTS FOR DIFFERENCE (CCfDs)

Even with subsidies or rebates that support the development of low-carbon technologies for emissions-intensive industry, deploying them at commercial scale remains a significant challenge. This phase between piloting a new technology and making it commercially viable is referred to as the "valley of death" in innovation literature; bridging this gap is critical to the widespread diffusion of breakthrough technologies and building markets for them (Neuhoff et al., 2019). Additional factors compound the challenge of deploying low-carbon technologies at scale in emissions-intensive industries. The scale of industrial plants makes upgrades capital-intensive, with long investment periods needed to recoup costs (Åhman et al., 2017). Shouldering the costs of investment requires a degree of certainty on the trajectory of carbon prices and assurances that an ETS will endure beyond a typical commitment period of 5-10 years, which present additional risks (Helm & Hepburn, 2005). Finally, as already discussed in section 3.2.2, manufacturers of industrial commodities face constraints in passing on investment costs in their prices without losing competitiveness.

One proposal to lower the risks of deploying low-carbon technologies for emissions-intensive industry is using project-based carbon contracts for difference (CCfDs). Similar to policies that guarantee certain price levels for renewable energy projects, CCfDs would ensure investors a fixed price for emissions reductions below the current best available technology. As developed by Richstein (2017), CCfDs pay out the difference between a reference price (e.g. the yearly average allowance price) and a price agreed to in the contract, effectively guaranteeing a certain level of revenue for the incremental costs of the investment (see also Neuhoff et al. (2019) and Sartor & Bataille, 2019). If the reference price exceeds the contract price, the investor would pay back the difference (see the illustration in Figure 6.1, which provides an example using the EU ETS, with the red line serving as the reference price of an ETS allowance).

Figure 6.1: Illustration of Carbon Contracts for Difference



Source: Sartor and Bataille, 2019

A number of design and administrative issues would need to be considered before such a policy could be introduced, including the criteria for the tender process, whether to include an additional grant element in the early years of the contract to cover learning costs, a methodology for determining contract prices, and appropriate benchmarks against which emissions reductions would be assessed (Sartor & Bataille, 2019; Richstein, 2017). For implementing jurisdictions that also support pilot demonstrations, this may provide an opportunity to scale up a technology that has been proven to work, helping to ease administrative burdens and leverage public funding more effectively (Sartor & Bataille, 2019). This would be the case for the EU, for instance, which has an architecture in place spanning the different phases of technology development and could use CCfDs as an instrument to scale up successful Innovation Fund projects. To help control expenditure, implementing jurisdictions could also prioritize industries for which a lower contract price would be effective and attractive.

BCAs or consumption charges could provide a source of revenue for CCfDs, and neither would eliminate the need for an additional instrument to de-risk capital-intensive investment, at least in the short-term. Carbon prices in implementing jurisdictions are still far too low to make many carbon-neutral technologies for the heaviest-emitting industries economically viable (Sartor & Bataille, 2019).

6.3 PRODUCT CARBON REQUIREMENTS (PCRs)

A tool that could enhance the effectiveness of carbon pricing and policies supporting low-carbon technologies on both the supply and demand sides of industrial materials are product carbon requirements (PCRs). PCRs for industrial commodities have not been extensively studied[30] but in essence would begin with labelling standards for certain industrial products linked to their emissions intensity, starting on a voluntary basis initially. ISO 14000 provides an example of a successful voluntary system, which is used to highlight the environmental-management practices of various types of organizations. The announcement of voluntary standards could be accompanied by longer-term targets on emissions intensity of materials covered under the PCRs to provide a signal to producers to enhance the effectiveness of technology and pricing policies that drive supply-side efficiencies and innovation in production processes. Voluntary standards with labeling would also empower consumers to choose lower-carbon options, which would help expand the market for climate-friendly goods and raise awareness of emissions embedded within the value chain (Neuhoff et al., 2018).

In a second phase, the implementing jurisdiction could establish mandatory PCRs. Such an approach would likely only take place in the later stages of an industrial decarbonization process, once there is enough capacity to produce low-carbon materials.[31] Where a product's technology roadmap is reasonably well-known, standards could play a significant role in supporting innovation, as California's zero-emissions vehicle standards have shown (Rissman et al., 2020). Mandatory PCRs would mean the sale of basic materials or products containing significant amounts of basic industrial materials would only be permitted in the implementing jurisdiction if they meet a certain threshold of emissions intensity. These standards could be based on the most efficient performers on the market to ensure they are commercially achievable and should be updated regularly to ensure they reflect continued progress (ibid). Japan's "Top Runner" policies are an example of this approach (ibid). Assuming technological advances have allowed for it, the implementing jurisdiction could require materials covered by mandatory PCRs to be certified as at or near climate-neutral, building on the existing system of voluntary standards.

To amplify the effectiveness of the mandatory PCRs, implementing jurisdictions could also take measures to prevent domestic industry from continuing to produce more emissions-intensive materials and exporting them to markets without mandatory standards (Gerres et al., 2019). Preventing such resource shuffling among producers outside the implementing jurisdiction, however, would likely prove more challenging unless other jurisdictions have enacted similar standards, which highlights the importance of coordination on standards across borders (e.g. bi- or -multilateral treaties or international organizations such as the International

[30] For the most extensive proposal to date, see Gerres et al., (2019)

[31] Analyses suggest this state will not be achieved until the mid-2030s at the earliest given the current state of technology development (Bataille et al., 2018).

Standards Organization).

Once mandatory, PCRs would help level the playing field between low-carbon and emissions-intensive materials, as both domestic producers and importers would need to comply to sell goods in the implementing jurisdiction (Climate Friendly Materials Platform, 2019). However, as with other command and control approaches, the lack of flexibility associated with mandatory PCRs could entail significant costs.

Critically, since mandatory PCRs would affect imported goods as well, implementing jurisdictions would need to consider WTO rules. They would most likely fall under GATT and the Agreement on Technical Barriers to Trade (TBT), which addresses issues such as product standards (Gerres et al., 2019). Jurisdictions would need to show, among other things, that PCRs do not provide preferential treatment to domestic producers and are applied even-handedly, without excessive administrative requirements (ibid). Announcing PCRs well in advance, which offers WTO members time to comment, and aligning them with international standardization bodies when possible would be advisable.

7 Conclusion

Achieving climate neutrality within the next three decades will require decarbonization of all sectors and negative emission technologies to compensate for residual emissions from hard-to-abate sectors. ETSs represent an attractive instrument to policymakers and are being deployed as a key mitigation response. However, concerns surrounding carbon leakage have resulted in all ETSs that cover industrial sectors providing free allocation. While there is very little evidence of carbon leakage occurring to date, this may suggest that free allocation of various forms has performed well in offering leakage protection, among other factors. Regardless, given increasingly divergent climate policy and related carbon costs as jurisdictions map their own pathway to net zero, concerns surrounding carbon leakage are likely to remain. This is particularly the case for the basic materials sectors, a group of homogeneous, low value-added commodities that are traded internationally and represent a large share of global emissions.

Free allocation as an approach to leakage protection

While there are different approaches to handing out allowances freely, most mature systems have moved towards a form of OBA. Systems of ongoing free allocation will face several upcoming challenges. While carbon leakage risk criteria determine the sectors eligible for free allocation, the total volume of allowances available is ultimately determined by the allowance cap as well as any regulation that dictates the share for auctioning. As ETSs move to more ambitious cap-reduction paths over this decade and the next, the total number of allowances available for leakage protection will decline. The question then becomes whether those sectors at risk of carbon leakage can reduce their emissions in pace with declining free allocation budgets or whether, at some point, they will be exposed to increasing carbon costs and hence leakage risk.

Addressing this concern will depend largely on where abatement opportunities lie for different industrial sectors and whether the allowance price, as mediated by the free allocation approach, will trigger the necessary reductions. For sectors where abatement potential depends on innovation in production processes and demand response to higher product prices, there is substantial risk that they will not be equipped to reduce their emissions sufficiently under current policy settings. This is largely due to the limited pass-through of carbon costs in the product price of materials, which creates two distinct problems. First, demand-side abatement potential is reduced. Second, firms cannot recover the costs of abatement technologies that require incremental costs through higher product prices but rather must rely on selling surplus allocation. This may not be a credible long-term investment framework as it relies on demand for allowances from other sectors that are decarbonizing as well as a commitment from policymakers to maintain free allocation.

Assessing carbon leakage risk

We have considered two responses to this challenge. The first is to adapt the carbon leakage risk criteria to better reflect actual risk and in doing so better align the sectors that receive free allocation with their leakage risk. However, based on a detailed assessment of the literature there is no clear choice of additional metrics or tests that could be applied alongside existing EITE criteria to improve broad leakage assessment. Additional tests come with caveats that would increase the complexity of leakage risk assessment, require significant additional data, and at times reduce the transparency of the approach. While additional criteria may capture legitimate risks of leakage that are not captured by existing approaches, allowing for additional criteria may also open alternative grounds for industry to inappropriately claim leakage risk.

Given these drawbacks, a second possible approach is adjusting the emissions and trade intensity thresholds for leakage protection. One model could be to increase the emissions-intensity and trade-exposure thresholds for qualification such that only those deemed to be of “high” risk qualify automatically. A more complex assessment with a wider range of criteria could then be applied to sectors at lower risk levels. The benefits of such an approach would need to be considered against the costs in terms of increased administrative complexity and reduced transparency. Another way to work with existing criteria would be to continue exclusively using emissions and trade intensity criteria but assigning different thresholds to different tiers (e.g. low, medium, and high)[32] and giving each tier different levels of free allocation.

Alternative approaches to address carbon leakage

Adjustments to the carbon leakage risk criteria may prolong the period for which enough allowances are available for leakage protection. However, it does not assist those sectors to decarbonize in a pathway consistent with net zero. Therefore, the time may be right in some jurisdictions to consider alternative approaches to maintain leakage protections that are compatible with the long-term transition to carbon neutrality. This is especially salient for ETS jurisdictions that face declining allowance budgets, where sectors considered at risk of carbon leakage make up a larger proportion of the allowance budget and there are divergences in carbon pricing across key trading partners in the near -to-medium term. Two options are BCAs and consumption charges combined with OBA. Both would present new administrative and political challenges relative to the status quo, but both would likely better incentivize abatement.

Designing and implementing a BCA involves trade-offs between the scheme’s effectiveness against carbon leakage and both its chances of meeting legal requirements under WTO rules and its administrative feasibility. That border adjustments have never been applied to carbon-intensive goods and lack WTO case law as a precedent underscore the need for a process that includes close engagement with the WTO for clarity on a legally robust design. This paper’s analysis of the academic literature and existing proposals suggests some guidelines for jurisdictions considering a BCA.

- **A BCA that is narrow in scope – at least at the beginning – is likely more administratively and legally feasible**: Limiting an initial BCA to only the most vulnerable EITE sectors and only imports may help balance the trade-offs inherent to BCA design while delivering environmental impact. Further products could be added later as budgets for free allocation decline and the scheme proves politically durable. This expansion could rely on analysis of the sector’s characteristics and could include additional metrics explored in chapter four, such as abatement potential/cost and market structure.
- **Different scopes of coverage may be appropriate for different sectors**: Leakage protections will vary sector by sector, depending on factors such as trade intensity. For some, an imports-only BCA will capture much of the benefits. An exports-only BCA offering rebates or exemptions for domestic production to overseas markets could be appropriate for some sectors in terms of leakage

[32] California and Québec use such a tier-based approach, but both apply 100% assistance factors regardless of risk classification. In California, 100% assistance factors are required through 2030 by legislation. Québec will differentiate assistance factors between 90-100% based on risk classification from 2021-2023. Total levels of free allocation in California and Québec will, however, decline based on declining cap adjustment factors.

protections but remains relatively unexplored in the academic literature and would present significant drawbacks.

- **Covering both direct and indirect emissions would improve the scheme's effectiveness and may be administratively and legally feasible**: Including both direct and indirect emissions would require multiple benchmarks and greater clarity from the WTO about legal ramifications if the implementing jurisdiction does not explicitly cover indirect emissions in its carbon-pricing system.
- **Benchmarks on direct emissions based on the implementing jurisdiction's production are likely more administratively and legally feasible**: Administrative and legal challenges likely preclude setting benchmarks based on the average emissions intensity of each exporting country individually or basing the adjustment on the actual verified emissions of each importer.
- **It may be advisable to avoid country-specific benchmarks on indirect emissions as well**: For similar reasons, benchmarks for indirect emissions that avoid country-specific determinations are likely easier administratively and legally. Region-specific benchmarks might help in these regards and offer a more effective response than a benchmark based on the implementing jurisdiction, but some authors have suggested the possibility of country-specific benchmarks for indirect emissions, and this could be further explored through engagement with the WTO.
- **Phasing out free allocation is critical to unlocking the abatement incentives of BCA, but a transition period may be advisable, especially to help secure industry support**: Continuing free allocation would mean removing the value of allowances granted freely from the adjustment importers face, but a transition approach may help assuage concerns of the industries covered under the scheme. It may also mitigate concerns of trade partners by reducing the adjustments they would face at the beginning.

Consumption charges paired with OBA may offer a promising alternative to BCA that would significantly improve abatement incentives on the demand side of the industrial value chain compared with current approaches. As an internal charge resembling a value-added tax that would be assessed on domestic production and imports alike using the same product benchmark based on the implementing jurisdiction's emissions intensity, consumption charges may prove more robust to WTO challenges than BCA, depending on the BCA's design. The WTO advantage over BCAs would likely hold, for instance, in the case of a BCA that includes export relief for domestic producers or benchmarks based on each importing country.

Consumption charges may also be administratively simpler, given that many jurisdictions already have extensive experience with value-added and excise taxes, along with the infrastructure to collect them. However, the extension of consumption charges to imports farther down the value chain that contain significant portions of covered materials would increase the administrative demands of the system, depending on inclusion thresholds and data availability. This potential for trade distortions farther down the value chain in response to unilateral leakage measures is a risk for BCA as well.

The need for continued, robust OBA to maintain leakage protections under consumption charges may present another challenge as jurisdictions phase down free allocation, particularly if this reduction occurs alongside continued discrepancies in carbon pricing abroad and EITE abatement has not kept pace with the decline in free allocation. Jurisdictions pursuing consumption charges would therefore need to consider measures to maintain leakage protections under consumption charges, such as reforms to allocation that would prioritize certain sectors for the remaining free allocation budget, or to transition to a mechanism that levels differences in carbon costs among trading partners. Similar to a system of free allocation without benchmarks, there is also a chance of greater leakage exposure as benchmark stringency increases and allowance prices increase while large discrepancies in carbon prices worldwide remain.

Lastly, unlike BCAs, consumption charges are not aimed at levelling discrepancies in carbon pricing between trading partners. This, combined with continued reliance on free allocation, may limit their potential to incentivize abatement outside of the implementing jurisdiction. Trading partners would have little reason to phase out free allocation if they would face consumption charges for their exports to a jurisdiction implementing consumption charges on top of their own domestic carbon price.

Additional policies supporting decarbonization

Ultimately, neither BCA nor consumption charges alone would likely be sufficient to fully incentivize emissions reductions on both the supply and demand sides of industrial commodities, at least in the near term. In some instances, carbon prices may be below what is required to incentivize certain technologies, while low-carbon investments for emissions-intensive industry are capital-intensive and entail incremental costs for potentially decades. These factors, compounded with the need for more innovation in breakthrough industrial technologies, underscore the need for additional supporting policies. Subsidies to support the deployment and development of low-carbon technologies for industry are one way to address these problems, while CCfDs offer an additional tool to de-risk deployment of promising innovations at a commercial scale, thereby creating lead markets. Product carbon standards may be another tool that would incentivize both greener consumption and production, especially if the standards were made mandatory after an initial voluntary phase.

Each of these policies would come with varying challenges, whether trade-based in the case of product carbon standards or raising equity concerns in the case of CCfDs, which would require significant amounts of capital made available to industrial sectors. But given the scale of the challenge, particularly on technology, they may warrant further consideration.

8 Appendix: Empirical assessments of carbon leakage

There is a growing body of research seeking to understand if and when carbon leakage occurs. This literature can generally be divided into two strands that tend to produce different outcomes regarding the evidence for competitiveness impacts. Ex-ante studies simulate potential carbon leakage effects using either general equilibrium approaches to examine the impact of carbon pricing policies on production and emissions outcomes at the level of the whole economy or partial equilibrium approaches to model output and emission patterns at the individual sector level. Ex-post research, on the other hand, analyzes existing policies and draws on real-world experiences by using econometric techniques to isolate the effect of the carbon pricing policy from other changes, or by using surveys. While ex-ante approaches tend to find some competitiveness and carbon leakage effects and usually with big differences in leakage rates (that is, the change in emissions in the rest of the world as a percentage of domestic emission reductions (Böhringer et al., 2010), ex-post studies usually find limited to no evidence.[33]

Four meta-analyses from Copenhagen Economics (2019), Vivid Economics (2018), Carbone and Rivers (2017), and PMR (2015) evaluate a comprehensive collection of ex-ante studies, covering general as well as partial equilibrium models. The literature reviewed by the PMR (2015) examines different time periods dating back to the early 1990s and looking ahead up to the early 2020s. Their general equilibrium studies comprise the entire EU ETS or specific sectors within the EU while their partial equilibrium studies mainly deal with multiple sectors on a global level. The analysis by Carbone and Rivers (2017) examines studies using general equilibrium models only, including 54 studies that mainly assess the competitiveness effects of energy-intensive industries in OECD countries. Vivid Economics (2018) reviews different ex-ante studies focusing on the sectors iron and steel, lime, cement, glass, pulp and paper, and chemicals in the EU ETS and California looking at different time periods between 1989 and 2012. Similarly, ex-ante studies reviewed by Copenhagen Economics (2019) scrutinize different sectors in European countries between 1995 and 2014.

All meta-analyses find evidence for competitiveness impacts and carbon leakage effects of carbon pricing mechanisms; however, their results vary considerably in terms of leakage rates and competitiveness levels. While general equilibrium approaches suggest comparatively low leakage rates ranging between 0-33%, partial equilibrium models assume a broad range of leakage rates between 0-100%. Concerning competitiveness levels, Carbone and Rivers (2017) find that, as a response to carbon pricing mechanisms, output, exports, and employment in EITE sectors might decrease and shift abroad.

The large range in leakage rates are in part driven by the varying assumptions used across models. For example, general equilibrium models often have difficulties capturing certain aspects of market structure and competitive dynamics. In particular, they rely on the parameters selected to estimate the extent to which traded products are substitutable between economies, on the substitutability of energy and non-energy factors of the production process, or on the elasticity of fossil fuel supply. The simplifying assumptions required to compute the model suggest the need to complement such modelling with empirical evidence when possible (Metcalf & Stock, 2020). Partial equilibrium models also do not capture feedback loops within the economy as prices and factors of production (e.g. labor, capital) adjust to the carbon price.

[33] PMR (2015); Ellis et al. (2019); Verde (2018); Aldy (2016); CPLC (2019); Arlinghaus (2015)

Ex-post assessments of carbon leakage have been steadily increasing (Verde, 2018). The latest meta-analyses on this topic include PMR (2015), Arlinghaus (2015), Verde (2018), Ellis et al. (2019), and CPLC (2019). All of these assess the EU ETS and its impact on carbon leakage and competitiveness concerns, while OECD (2019) includes other G20 and OECD countries' carbon pricing mechanisms. CPLC (2019) also includes Canadian carbon pricing. All of these meta-analyses of ex-post research come to the conclusion that there is no or only very limited evidence of carbon leakage or competitiveness impacts.[34]

Most of these meta-analyses review studies that test for competitiveness indicators which are then applied as a measure for carbon leakage. However, there are two recent ex-post studies that directly test for carbon leakage. Dechezlepretre et al. (2014) examine the impact of the EU ETS on the geographical relocation of carbon emissions within multi-national companies making use of a combination of firm-level carbon emissions data with financial information. Naegele and Zaklan (2017) analyze the existence of carbon leakage in the EU ETS by using a dataset of global trade flows, emission costs, and different control variables. Neither study finds evidence of carbon leakage, although Naegle and Zaklan (2019) note that region-specific productivity shocks could potentially be confounding seemingly negligible estimated ETS effects on leakage.

Although the evidence of all of these evaluations, in contrast to ex-ante literature, suggests that there is no significant evidence for competitiveness impacts and carbon leakage, this does not imply that carbon leakage is not a threat going forward. Two main factors combine to limit the impact of leakage from existing carbon pricing mechanisms. The first is relatively low carbon prices. It may also be that other factors such as corporate tax rates, wages, and labor availability have been more significant factors in determining output or investment decisions (CPLC, 2018). As such, at low carbon prices firms may tolerate carbon price differentials so long as market and other factors promote their competitiveness. A second factor is that all existing carbon pricing mechanisms have protected those sectors considered to be most at risk of carbon leakage with either free allocation, rebates, or exemptions.

A further problem arises as much of the literature studies short-term effects of carbon pricing instruments while competitiveness issues that may ultimately lead to industry relocation and carbon leakage are more likely to occur in the long term. However, EITE sectors in particular are faced with comparatively longer time spans between decisions to relocate and a measurable impact on production capacity and output (Verde, 2018; Ellis et al., 2019).

Another restriction to the validity of the reviewed studies' outcomes can be limited availability of firm level or sector specific data to feed into econometric models. This influences the accuracy of the analysis and can distort the results to the extent that there is not sufficient data on companies' competitiveness indicators to produce reliable results. A final concern on validity of results is that relevant data is only available for certain sectors or regions, and if they are less prone to competitiveness concerns this would produce biased conclusions about the risks of leakage (Vivid Economics, 2014).

[34] PMR (2015); Arlinghaus (2015); Verde (2018); Ellis et al. 2019; CPLC (2019)

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