WP/21/239

IMF Working Paper

Border Carbon Adjustments: Rationale, Design and Impact

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INTERNATIONAL MONETARY FUND

 WP/21/239

IMF Working Paper

Fiscal Affairs Department

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Authorized for distribution by James Roaf

September 2021

Abstract

This paper assesses the rationale, design, and impacts of border carbon adjustments (BCAs). Large disparities in carbon pricing between countries raise concerns about competitiveness and emissions leakage. BCAs are potentially the most effective domestic instrument for addressing these challenges—but design details are critical. For example, limiting coverage of the BCA to energy-intensive, trade-exposed industries facilitates administration, and initially benchmarking BCAs on domestic emissions intensities would ease the transition for trading partners with emission-intensive production. It is also important to consider how to apply BCAs across countries with

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different approaches to emissions mitigation. BCAs alone do not solve the free-rider problem in carbon pricing, but might be a step to an effective international carbon price floor.

JEL Classification Numbers: Q31; Q35; Q38; Q48; H23.

Keywords: border carbon adjustment; climate mitigation; carbon pricing; competitiveness, emissions leakage; allowance allocation, design issues, World Trade Organization rules.

1. Introduction

As countries consider more aggressive climate mitigation policies, the question of whether some form of 'border carbon adjustment' (BCA) is appropriate has become central to the wider climate debate. The EU's recent announcement of a BCA proposal in July 2021[1], as well as BCA proposals in the United States[2], have heightened interest in this instrument, not least as countries are revising their climate strategies in the run up to COP26 in November 2021.[3] Underlying this interest is a concern that more ambitious unilateral actions—higher domestic carbon pricing, in particular—will be discouraged by cross-border effects. The interest in BCA is as a possible way to limit the harm that can arise from lack of uniformity in and coordination of national policies. Put differently, carbon pricing, as is well-known, faces a fundamental free-rider problem, since each country has an incentive to leave it to others to address the common climate challenge: BCAs may be a way to help address this difficulty.

A 'BCA' here is taken to be a charge on the carbon content of imported products intended to ensure treatment equivalent to domestic carbon pricing, potentially combined with rebates for the carbon content of exports. Two features of this approach should be noted. First, and most straightforwardly, the term 'charge' reflects that the BCA could be implemented either as an explicit tax, or as a requirement for importers to purchase allowances from a domestic emissions trading system (ETS) or separate allowance pool. Second, the remission of tax on exports is treated as an optional feature—and indeed many proposals do not allow for such rebating. Without such an adjustment, however, a BCA is different from a 'border adjustment' in the sense that the term is used, for example, in relation to the VAT: there it is used to indicate that imports are effectively brought into domestic taxation, and exports taken out, so placing the tax on a 'destination' basis. This points to a potential tension in that the Paris Agreement, in contrast, assigns to countries responsibility for the emissions generated within their borders – an 'origin' basis.[4]

Policymakers are considering BCAs for three main reasons:

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[1] The proposed BCA would become operational in 2026 following a transition period. See https://ec.europa.eu/info/sites/default/files/carbon_border_adjustment_mechanism_0.pdf.

[2] See https://joebiden.com/climate-plan. Recent legislative proposals for carbon taxes in the United States have also contained BCAs (see www.carbontax.org/bills).

[3] See for example www.aljazeera.com/economy/2021/2/5/bb-uk-pm-to-push-allies-to-agree-on-carbon-border-taxes-report. Only one BCA has been implemented to date, and at the sub-national level—it applies to the embodied carbon in imported electricity under California's ETS (see Bushnell and others 2014, Pauer 2018).

[4] A third feature is that this definition excludes equalization with respect to domestic abatement measures other than carbon pricing: the treatment of non-price measures is discussed in Section 2.A

- To help *preserve the competitiveness of domestic industries* in the presence of domestic carbon pricing, particularly for energy-intensive, trade-exposed (EITE) industries—this improves economic efficiency in the sense of preventing distortions in the relative prices of domestic and foreign goods (i.e., clean and polluting industries at home and abroad are treated alike)[5] and can aid the political acceptability of carbon pricing;

- To reduce the risk of *emissions leakage*, that is, partially offsetting emissions increases in foreign countries induced by domestic mitigation policy—this objective signals a concern not only with national welfare but with global welfare more generally;[6] and

- At an international level, some have stressed that BCAs may *strengthen incentives for carbon pricing and mitigation action in other countries*—there is a direct fiscal incentive to the extent that non-BCA countries effectively forgo revenue on their exports collected by the importing BCA country, and indirectly BCAs might help to strengthen the international credibility of carbon pricing schemes.

While related, these objectives are distinct: it will be seen, for instance, that leakage may be significant even if the competitiveness effects of domestic carbon pricing—in the sense of a decline in domestic production—are small, and *vice versa*.

Policymakers considering BCAs will need to address two broad sets of issues:

- How BCAs might be best designed (e.g., through choice of sectoral coverage, measurement of embodied carbon in traded goods, treatment of exports, accounting for mitigation actions in foreign countries); and
- Whether BCAs are preferable to other instruments (e.g., free ETS allowance allocations to EITE industries) for addressing their underlying objectives.

In making these choices, policymakers will also need to consider the preservation of domestic mitigation incentives, the impact on revenue, moderating administrative and compliance costs, and limiting risks of challenges under World Trade Organization (WTO) rules or of trade retaliation.

It will be important for policymakers to consider the likely reception of a BCA by their international partners. Just as it is natural for the country implementing carbon pricing to be concerned about competitiveness and carbon leakage, so it is also natural for trading partners to be

[5] This is of course just one aspect of efficiency: the impact on the aggregate level and cross-country distribution of emissions is another.

[6] Adopting an explicitly global standard of efficiency, a form of BCA can indeed be shown to be required when carbon prices are not appropriately set in all countries. See Keen and Kotsogiannis (2014).

concerned that BCAs might camouflage protectionist measures. The impacts of carbon pricing and the BCA should be considered jointly: rather than being seen as creating a competitive advantage for the country imposing it, a BCA may be better thought of as mitigating a competitive disadvantage that its carbon pricing would otherwise create for itself by raising costs on domestic producers. Further, to the extent that countries with carbon pricing are already using measures such as free emissions permit allocations in pursuit of their objectives, a BCA would simply replace one mechanism with another. These considerations may alleviate trading partners' concerns about the BCA—so long as it is designed appropriately and does not over-compensate for the cost increases caused to the domestic industry by carbon pricing.

This paper seeks to provide practical guidance for policymakers, both conceptual and quantitative. Conceptually, we focus throughout on the analysis of BCAs from a national rather than a collective perspective. Key empirical issues to which the analysis points include leakage rates, burdens of BCAs on trading partners, emissions shares of traded products, embodied carbon in imports and exports for different countries, and the impacts of BCAs on industrial costs.[7]

The paper is organized as follows. Sections 2, 3, and 4 focus on potential rationales for BCAs, design issues, and instrument choice issues respectively. Section 5 provides brief concluding remarks. Although the focus is on the tax policy aspects of BCAs, this cannot meaningfully be addressed without recognizing the legal context, a brief account of which is given in Annex 5.

2. Rationales for BCAs

We consider in turn the three possible rationales for some form of BCA set out above.

Competitiveness

Carbon pricing can affect the competitiveness of emissions-intensive domestic industries, by increasing their costs relative to foreign competitors. Around 30 carbon pricing schemes had been implemented by 2021 at the national and EU levels, with prices and coverage varying widely (and many not applying to the industrial sector)—see Figure 1. Implicit carbon prices in mitigation pledges for 2030 also vary widely.[8] While some price dispersion may well be acceptable—for example, reflecting the principle under the Paris Agreement that countries have "common but differentiated responsibilities" according to their level of development—it may be difficult for countries to implement

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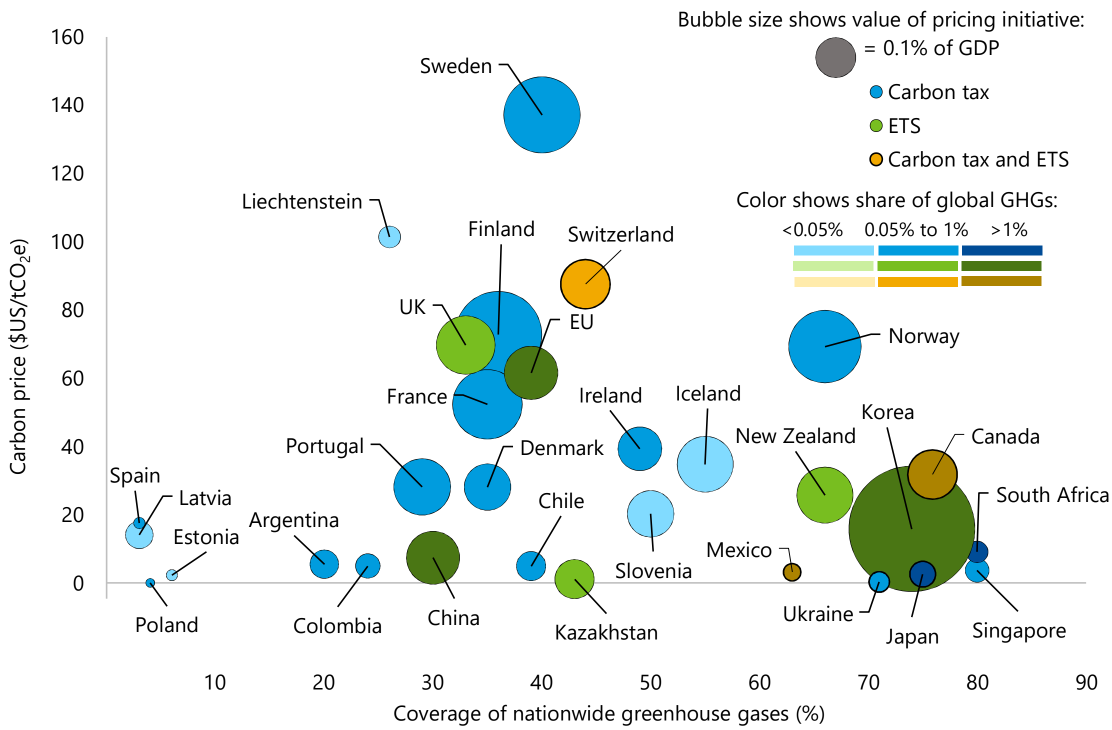
[7] The analysis complements other recent discussions, for example, Chen and others (2020), Cosbey and others (2019), Flannery and others (2018), Lowe (2021), Morris (2018), OECD (2020).

[8] IMF (2019a, b).

aggressive near-term pledges without mechanisms for limiting perceived declines in their international competitiveness.

Figure 1. Selected Carbon Pricing Schemes, 2021

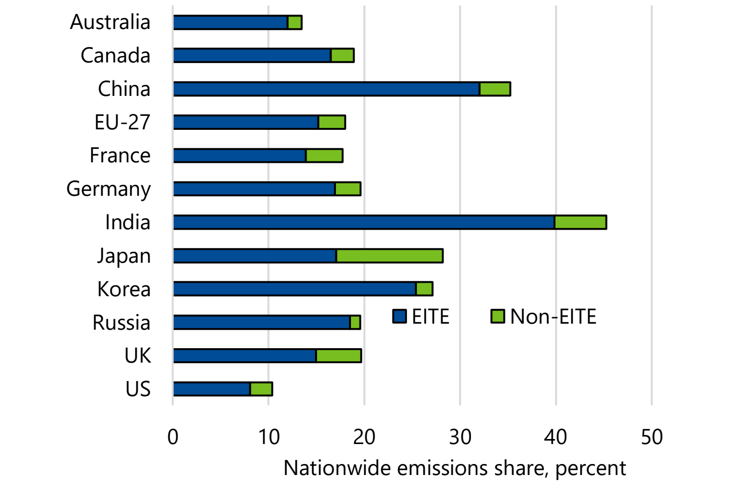


Sources: WBG (2021); EMBER (2012); Climate Watch (2021); IMF staff calculations.
Notes: Carbon prices are from April 01, 2021 from WBG (2021). EU ETS price is from July 19,2021 from EMBER. GHGs are from 2018. EU includes Norway, Iceland, Liechtenstein. Values less than 0.005 percent of GDP are of equal size for illustrative purposes. The value of the UK's ETS is an estimation for 2021 based on a £50/tCO_2e price. China's value estimate and price is based on the opening pricing of $7.40/t$CO_2$e. Finland's transport fuels are priced at $73/t$CO_2$e. Ireland's F-gases are priced at $20/t$CO_2$e . Norway has a reduced rate on natural gas for EU ETS installations of $4/t$CO_2$e. Norway and Mexico prices represent carbon price upper bounds. Lower bounds are $3.9/t$CO_2$e and $0.37/t$CO_2$e respectively. Switzerland's price is a weighted average between carbon price and ETS by emissions covered.

While competitiveness concerns apply in principle to all traded items, the policy focus has been on EITE industries. This is because their costs are most heavily increased by carbon pricing (since their production is energy intensive) and there is a reasonable presumption that demand for these products may shift significantly from domestic to foreign suppliers under carbon pricing. Moreover, EITE industries are typically 80 percent or more of manufacturing emissions—though manufacturing is usually around 10-30 percent of nationwide emissions (Figure 2). EITE industries may also have particular political sensitivities, given that employment effects of carbon pricing may be larger and more visible than for other sectors.

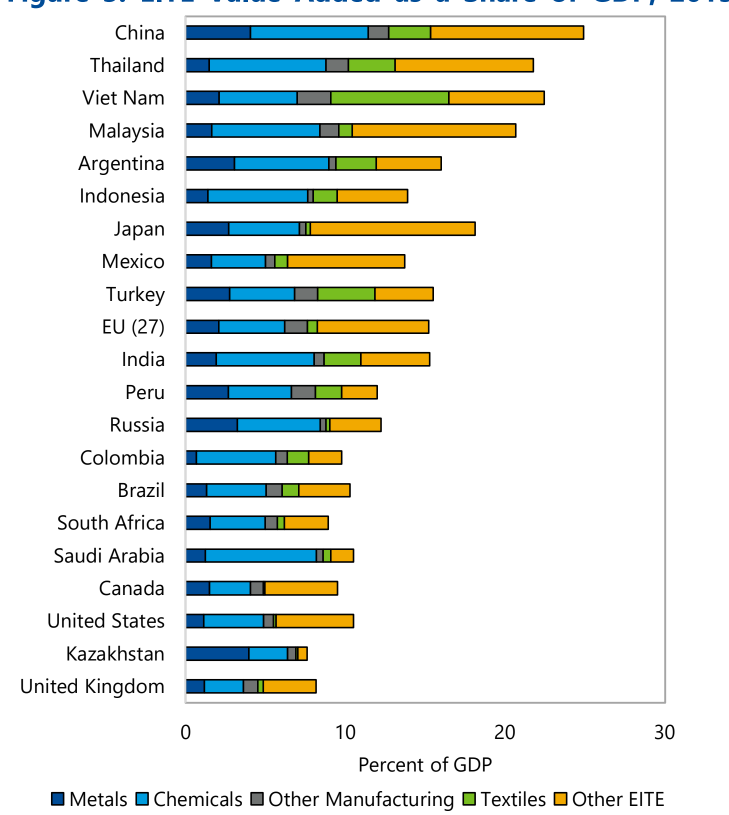
Primary examples of EITE industries include iron, steel, aluminum, refined petroleum products, pharmaceuticals, plastics, glass, ceramics, cement, textiles, and wood products. Many of these industries produce raw materials for sale to firms further down the value chain producing final consumer goods. In the EU ETS, for example, industries are classified as EITE if the ETS increases their production costs at least 5 percent and their trade share with non-EU countries (imports plus exports relative to production) is above 10 percent; these industries are currently eligible for free allowance allocations determined by their historical production and by industry emission rate benchmarks for relatively clean firms.[9] In principle, electricity should count as an EITE industry under the EU criteria (as it is in California) but it is excluded as production costs are largely passed forward in higher consumer prices (see below) despite some trade exposure. Agriculture is another potential EITE industry, but (proxy) pricing schemes have not yet been applied to most greenhouse gas emissions from this sector. EITE industries typically account for around 10-20 percent of GDP (Figure 3).

Figure 2. Nationwide CO_2 Shares for Domestic EITE and Manufacturing Industry, 2015



Source: OECD (2021); UNFCCC (2021).
Note: EITE includes metals, chemicals, wood/paper, and textiles. Nationwide emissions exclude land use and land use change.

Figure 3. EITE Value Added as a Share of GDP, 2015

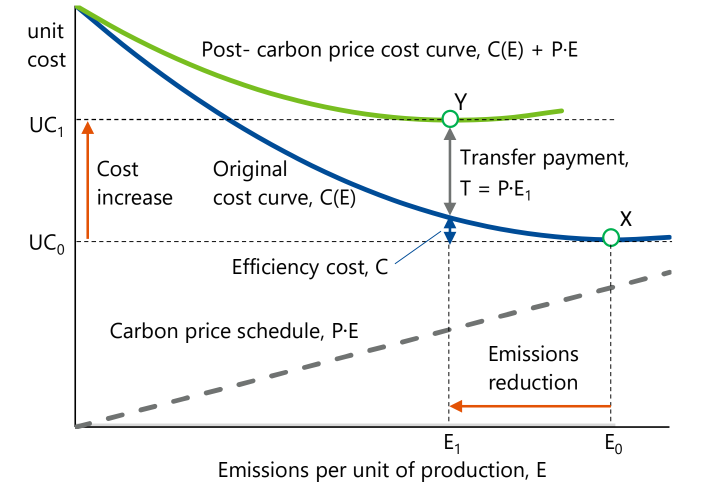


Sources: OECD TiVA Database; IMF staff calculations.

[9] Sectors are also deemed EITE (i.e., at significant risk of carbon leakage)) if production cost increases or their trade share exceed 30 percent (see https://ec.europa.eu/clima/policies/ets/allowances/leakage_en). The industries defined as an EITE will vary across countries with differences in classification criteria, energy intensity, and trade exposure (Cosbey and others (2012).

The anatomy of the competitiveness issue is shown in Figure 4. Carbon pricing drives a wedge between pre- and post-tax production cost curves. In the absence of carbon pricing, the curve C(E) shows unit costs as a function of emissions per unit E (both direct and indirect—see below). The firm chooses to produce at the minimum cost, at point X, with emissions of E_0. Introducing a carbon price of P per unit of CO_2 raises the cost curve to C(E) + P·E. The firm now optimizes at point Y. Emissions per unit fall from E_0 to E_1, and unit production costs rise from UC_0 to UC_1.

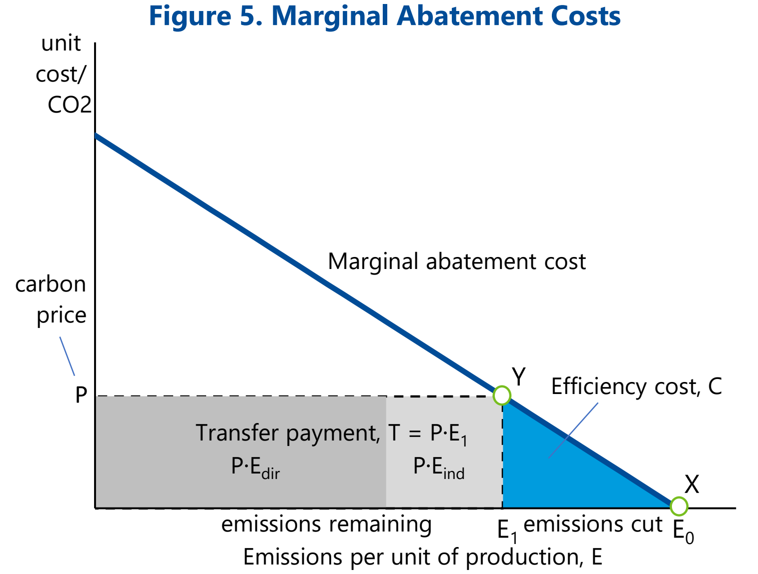
Figure 4. Impact of Carbon Pricing on Firm Cost



Source: IMF staff.

The increase in unit production costs has three main components. Figure 5 shows the same information as Figure 4, but (on the vertical axis) on a per-unit of emissions basis (rather than per unit of output). The first cost component, C, is the efficiency or social cost of the induced changes in production methods (e.g., the cost of switching to cleaner technologies and fuels), indicated by the relevant area under the marginal abatement cost schedule. Next is the transfer payment to the government (or to allowance sellers), T, equal to the carbon price times the remaining emissions per unit of output—this is a private rather than social cost (C and T correspond to the vertical distances marked in Figure 3). Viewed from the perspective of a particular firm, this transfer cost can be divided further into payments made on: (i) the firm's direct emissions ($P{\cdot}E_{dir}$); and (ii) indirect emissions embodied in the firm's inputs, in practice likely to be chiefly electricity ($P{\cdot}E_{ind}$).[11] At moderate abatement levels, the efficiency

Figure 5. Marginal Abatement Costs



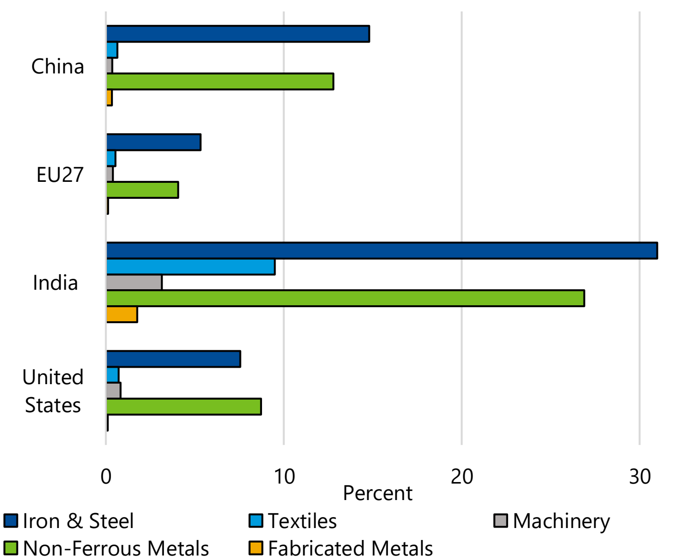
Source: IMF staff.

[11] Direct and indirect emissions are sometimes referred to as scope 1 and scope 2 emissions respectively.

cost is small relative to the transfer payment, with the relative size of the efficiency cost rising with the extent of abatement.

Unit production cost increases from carbon pricing by itself would vary significantly across countries and EITE industries. For illustration (see Figure 6), a carbon price of $50 per ton in 2030 is estimated to increase unit costs for basic metals by around 25-30 percent in India, 12-15 percent in China, and less than 10 percent in the EU and US, while cost increases for textiles, machinery, and fabricated metals are less than 10 percent in each case (Figure 6). Empirical studies, however, have generally failed to identify large production effects of carbon pricing, albeit at generally low levels of carbon pricing and often in the presence of compensating instruments such as free allowances.[12] And while there has been a general sense that EITE cost increases are difficult to pass forward in higher prices to downstream firms or consumers, solid empirical evidence on this has been difficult to pin down.[13]

Figure 6. Input Price Changes for $50/tCO2 Carbon Tax, in percent, 2030



Source: IMF staff calculations.
Note: EU27 uses a weighted average on sectoral output.

A BCA could level the playing field, in terms of carbon charges, between sellers from different jurisdictions competing in the same market. A BCA charging the carbon content of imports (direct and indirect) at a rate equal to the difference between domestic and any foreign carbon prices, and symmetrically for exports, would fully adjust for differences in carbon prices. For imports from a jurisdiction without carbon pricing or other mitigation policies, such a charge means the foreign producer faces the same transfer payment component (T in the diagrams above) as a domestic producer with the same emissions intensity. Similarly, including export rebates in the BCA will put the domestic producer on level terms with foreign producers in the external market. The competitiveness

[12] For example, Dechezleprêtre and Sato (2017), Venmans and others (2020).

[13] Most studies suggest pass through rates for EITE industries of between about zero and 50 percent (Neuhoff and Ritz 2019) in contrast to the power sector where carbon pricing in the EU has been largely passed forward in higher consumer prices (e.g., Bushnell and others 2013, Sijm and others 2006).

impacts of the BCA will depend on key design features however, most notably the measurement of embodied carbon (see Section 3).

Some form of border adjustment by countries using regulations or other non-price mitigation policies could also be warranted. Non-price policies differ fundamentally from price-based policies in that they do not impose on firms the rectangle of tax-transfer shown in Figure 4. However, both price and non-price policies increase production costs by the triangle C : the efficiency cost being forced in the case of non-price policies by a notional shadow price of carbon. So nonprice policies generally impose markedly lower private costs on firms than carbon pricing (at equivalent shadow prices). Nonetheless, these costs could still be significant enough to cause competitiveness and leakage concerns, especially at higher levels of domestic abatement. Conceptually they would therefore merit some type of charge on imports from jurisdictions with little or no mitigation in place.

However, in such circumstances a BCA that charges the domestic shadow price on embodied emissions in imports would generally not be the appropriate response. This is because the domestic firm is expressly not paying a price on its own embodied emissions: instead, the cost to the domestic firm arises only from the *reduction* in emissions. It would also be problematic from a legal point of view to impose charges on imports that are not being paid by domestic firms. The objective of restoring competitiveness would seem best met by charging imports some estimate of the efficiency cost faced by domestic firms.[14] This though faces two practical constraints: the efficiency costs are unobserved, unlike actual carbon pricing transfer costs; and this approach would not fit within WTO rules, so would depend on interpretation under the "environmental exception". Further, it is very hard to see how compensation for efficiency costs could be effected for exports without falling foul of WTO rules on subsidies.

The issue is explored further in Annex 1, examining the cases in which either the import country (as above) or the exporting country uses regulations or other non-price policies. One key implication of the difference discussed above between actual and shadow carbon pricing is that a country using carbon pricing that adopts a BCA could well choose to apply it to imports from a country achieving equivalent emissions reductions through regulations.

B. Leakage

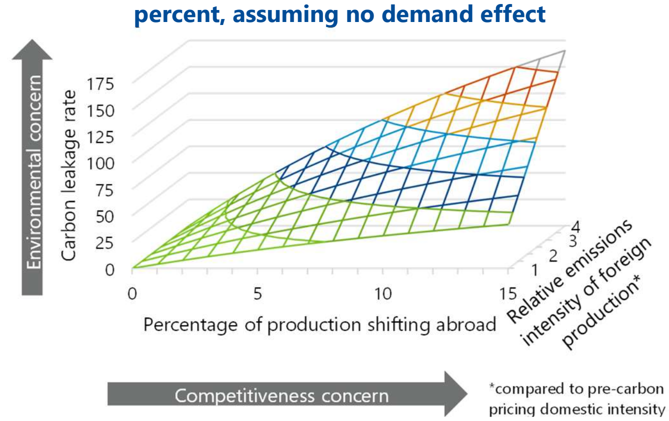
Unilateral carbon pricing creates the risk that reductions in domestic emissions will to some degree be offset by additional emissions from increased production abroad—a risk that BCAs can reduce. Such leakage can arise from the international migration of production, or an expansion

[14] An alternative, beyond the scope of border adjustment, would be to apply the same regulatory standards to imports as faced by domestic firms, which would amount to banning high-emissions imports altogether, which raises its own legal and trade policy issues.

of existing production abroad, following a deterioration in the relative competitiveness and/or profitability of operating in countries imposing carbon pricing—offsetting charges on imports and (see below) remitting tax on exports can mitigate these risks. This type of leakage is most relevant for EITE industries—in contrast, for example, CO_2 emissions from domestic transportation and buildings are largely immobile.[15]

At the industry level, the potential leakage rate (i.e., the increase in foreign emissions relative to the reduction in domestic emissions) is not always related to the scale of competitiveness impacts. The reduction in domestic industry emissions induced by carbon pricing can be decomposed into three effects: a reduction in the emissions intensity of domestic production (as firms adopt cleaner technologies and fuels); a reduction in domestic production due to lower domestic demand; and a reduction in domestic production due to migration of production away from domestic to foreign firms. Only the last channel causes leakage. Leakage generally goes hand-in-hand with competitiveness concerns but—depending on the relative foreign emissions intensity—it is possible to have relatively high leakage rates with small shifts of production. For example, as shown in Figure 7 (holding domestic demand constant for simplicity), if carbon pricing incentivizes a 25 percent reductionin domestic industry emissions intensity, and 5 percent of production to shift abroad, then the leakage rate for the industry will be 35 and 70 percent respectively if the emissions intensity of foreign production is 200, and 400 percent of that for domestic production[16]—see further discussion in Annex 2.[17]

Figure 7. Determinants of Leakage Rates
for EITE under domestic emissions intensity reduction of 25 percent, assuming no demand effect



Source: IMF staff calculations.

Empirical evidence on national level leakage rates is mixed, though they can be significant and tend to be larger for small open economies. Most of the empirical literature finds modest or no

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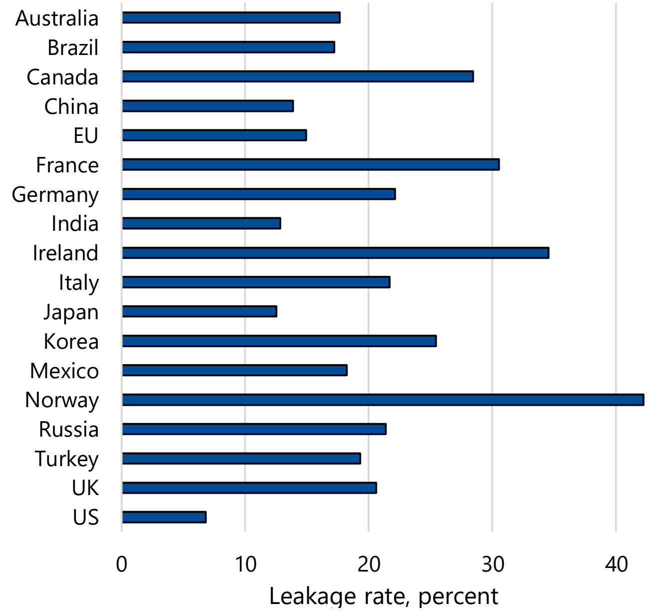
[15] International aviation and maritime are internationally mobile sectors but responsibility for mitigating their emissions lies with the United Nations bodies overseeing these industries.

[16] The approximation for the leakage rate set out in Annex 2 (with $\hat{D}$ set at zero) of e*/e . $\hat{Y}$ / ($\hat{Y}$ + ê), gives 33 and 67 percent for e*/e equal to 2 and 4 respectively.

[17] Note that the leakage calculations in Figure 6 are symmetric in exports and imports: they are the same whether the domestic country is a net importer or net exporter of the product initially, or whether the leakage occurs through an increase of imports or a reduction in exports.

evidence of leakage, though in part this may reflect the limited scope of carbon mitigation policies adopted so far and methodological limitations (see Annex 3). One recent study suggests higher leakage rates—while the absolute figures should be treated with caution, the study also provides insight on the pattern of leakage across countries. On average in this study (Figure 8) carbon leakage amounts to 25 percent, with rates varying from 20 to almost 50 percent in individual European countries, but less than 15 percent in China, the EU14+UK aggregate, India, and Japan, and 7 percent in the US. Overall, leakage rates are larger for small open economies, such as most individual EU countries—though that does not mean that leakage is inherently less of a concern for larger countries, since the absolute level of emissions at stake is larger.

Figure 8. Estimated National Level Leakage Rates



Source: Misch and Wingender (2021).
Note: Estimates for EU countries include leakage from them to other EU countries and non-EU countries.

Leakage might also result from increased fossil fuel demand in foreign countries in response to downward pressure on international fuel prices from countries taking mitigation action. This form of leakage would be zero for unilateral mitigation for a small country that is a price taker in international fuel markets but could be significant for a group of larger countries.[18] However, as this form of leakage depends on the reduction in aggregate consumption of fossil fuels in mitigating countries, it is essentially unaffected by both the form of mitigation instrument (carbon pricing or other) and any accompanying measures (BCA or other).

National limits on emissions under the Paris Agreement may address leakage, to the extent that they bite. Under the Paris framework, countries are responsible for production emissions (i.e., emissions released within their own borders). Potential emissions leakage in foreign countries (due to increasing production or fuel demand) might therefore be neutralized by stronger mitigation policies if those foreign countries honor a binding target on nationwide emissions. In practice however, pledges for the Paris Accord are voluntary, may not be fully achieved, and they do not always take the form of nationwide emissions caps.[19]

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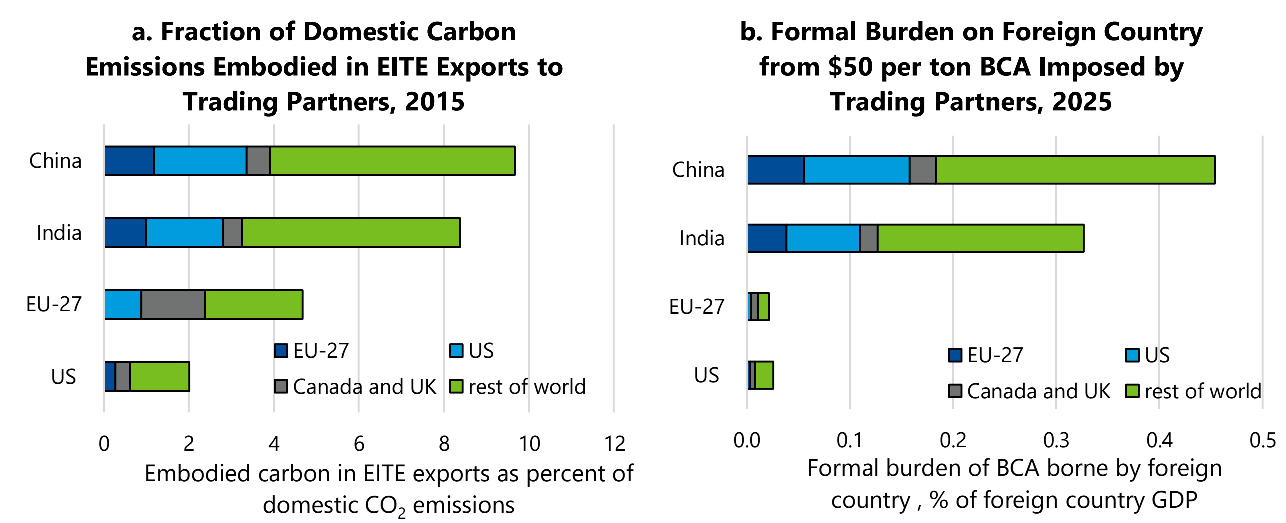
[18] See, for example, Fischer and Fox (2012), Kuik and Marjan Hofkes (2010).

[19] For example, China and India have set emissions to GDP targets for 2030 which would accommodate some increase in nationwide emissions if leakage increases their GDP.

C. Promoting Carbon Pricing in Other Countries

Inherent in any BCA is a fiscal incentive for trading partners to impose some carbon pricing—but the incentive appears modest given the small shares of emissions in trade flows. By raising carbon pricing on its exports to the level in the BCA-imposing country (thereby eliminating liabilities under the BCA) a foreign country would transfer tax revenue from the BCA country to itself. This incentive will be stronger the greater are: (i) the BCA charge; and (ii) the share of CO_2 emissions embodied in foreign countries' exports to BCA-imposing countries. For illustration, carbon embodied in EITE exports from China and India to the EU and US are only about 3 percent of China and India's domestic carbon emissions—the formal incidence on China and India of a $50 BCA imposed by the EU and US would be only 0.1-0.15 percent of the former's GDP (all statistics from this paragraph are from Figure 9a and b). Moreover, the effective incidence—the burden that remains with Chinese and Indian producers—is likely to be much lower than this because much of the import charge is likely passed forward to domestic consumers in the EU and US in the form of higher product prices. All this implies only a modest incentive for these countries to scale up carbon pricing throughout the wider economy in response to EU and US BCAs. The incentive would be slightly stronger if a broader range of countries were to impose BCAs—embodied carbon in EITE exports to all trading partners from China and India is 10 and 8 percent of their domestic carbon emissions respectively, and the formal incidence would be approximately 0.45 and 0.3 percent of GDP for China and India respectively. In contrast, embodied carbon in the EU-27 and US EITE industry exports to the world is only 5 and 2 percent of domestic emissions, and the formal incidence of a BCA imposed by the rest of the world on them is less than 0.05 percent of their GDP.

Figure 9. Emissions Shares in Trade Flows and Burdens of BCA on Trading Partners



Source: OECD (2021).

Source: OECD (2021); IMF staff calculations.

BCAs may, however, also promote pricing in other countries in less tangible ways. For example, as countries reinforce carbon pricing with BCAs, they send a clear message that carbon pricing is the centerpiece of their mitigation strategy, which may influence other countries deciding how much to rely on carbon pricing in their own mitigation strategies. In addition, even if BCAs are initially introduced unilaterally, countries may subsequently coordinate to create border free trading zones with a common external charge, which may ultimately lead to more formal and comprehensive arrangements for coordinating over carbon pricing.

A BCA in combination with other incentives could promote participation in an international carbon price floor (ICPF) arrangement among large emitting countries. The purpose of an ICPF would be to facilitate a scaling up of global carbon pricing (or equivalent measures) through coordinated action to address free-rider and competitiveness obstacles that hamper countries when they act unilaterally.[20] It would be far more effective in scaling up global mitigation than, and potentially even avoid the need for, BCAs, given BCAs price only carbon embodied in trade flows rather than all emissions (see Annex 4). BCAs might be applied by ICPF participants to non-participants, though this could complicate discussions over designing the ICPF, due to the need to agree on terms for the BCAs as well as for the ICPF itself.

3. Design Issues for BCAs

Designing a BCA is challenging, as there are multiple objectives and design features to consider. Beyond the three focused on above, other objectives include preserving domestic mitigation incentives, raising revenue, and limiting both administrative/compliance burdens and risks of WTO challenges. Legal risks are difficult to gauge ex ante, not least because trade rules were written before the recent attention to BCAs—they are discussed in Annex 5. In essence, WTO rules permit countries to adopt harmonizing measures (e.g., BCAs) for indirect taxes and a key uncertainty is whether carbon pricing counts as an indirect tax (likely more difficult for an ETS than a carbon tax). There is also uncertainty about whether a charge varying by the exporting country's carbon intensity would violate the Most Favored Nation (MFN) principle which precludes differentiation based on the country-of-origin of the imports. If a BCA does not meet these rules, it might nonetheless qualify as an exception under Article XX if it is viewed as addressing environmental issues (i.e., emissions leakage), though demanding legal tests must be met in this case. Table 1 summarizes the implications of design features for meeting multiple objectives; the discussion below elaborates on the main points.[21]

The discussion below does not distinguish between BCAs in the form of an import tax versus an allowance purchase requirement, as the latter can be designed to mimic the former, though price uncertainty may be greater. A simple requirement to acquire allowances from a domestic ETS to cover embodied carbon for imported products (without changing the total allowances available in

[20] See Parry and others (2021).

[21] See also OECD (2020).

Table 1. Design Choices for BCAs and How they Affect Multiple Objectives

Metric	Design Feature: Sectoral coverage: EITE industries vs. broader (all manufacturing, services, etc.)	Measuring embodied carbon: Domestic vs. country-specific benchmarks	Measuring embodied carbon: Recognize foreign firms with lower embodied carbon	Rebates for domestic exporters	Revenue use	Lowering import charges for carbon pricing abroad	Exemptions for least developed countries
Protecting competitiveness of EITE industries	Either approach provides same protection	Country-specific preserves relative domestic/foregin prices despite carbon pricing	Little relevance	Preserves competitveness of exports	Little relevance	Appropriate for preserving level playing field	Little relevance
Limiting leakage	Broader coverage addresses leakage for more products but the benefits may be modest	Country-specific addresses leakage more efficiently	Little relevance	Reduces leakage	Little relevance	Can help reduce leakage	Little relevance
Promoting mitigation and carbon pricing in other countries	Broader coverage increases the base of charges on imports from trading partners	Country-specific provides stronger incentives on foreign producers and govts.	Gives incentive on foreign firm to reduce emissions	Little relevance	Little relevance	Promotes pricing but direct incentives may be modest	Little relevance
Mitigation incentives for domestic EITE industries	Either approach preserves incentives	Either approach preserves incentives	Little relevance	Preserves incentives if designed appropriately	Little relevance	Little relevance	Little relevance
Revenue implications	Broader coverage increases revenue from import charges (and revenue losses from export rebates)	Country-specific raises more revenue if trading partners have higher embodied carbon	Small reduction in revenue	Loses revenue	Not applicable	Reduces revenue	Forgoes some revenue
Administrative burden	Complex for broader coverage (more products, difficulties in measuring embodied carbon)	Administration for country-specific is more complex	Small if third parties provide verification	Additional burden but modest	Not applicable	Adds to burden, limited by EITE focus	Modest reduction
Risk of legal challenge under WTO	Leakage rationale more questionable for broader BCA	Domestic might help by reducing tariff and showing like treatment	Rebuttability provison should help with WTO compatibility	May be challenged as a subsidy	Using revenues for green transtion or intl. finance may reduce legal risks	May increase legal risks if not applied equally and equivalently across countries	Possible
Preliminary recommendation	***EITE*** *(at least initially)*	***Domestic initially to ease transition; later aim for country- specific***	***Yes***	***Yes***	***Consider environmental uses***	***Yes*** *(or mutual BCAs each with export rebates)*	***Yes***

Source: IMF staff.

the ETS) may be undesirable as it would put upward pressure on, and increase uncertainty about, allowance prices—embodied carbon in EITE imports to the EU in 2015, for example, was equivalent to about 15 percent of the allowable ETS cap.[22] One approach would be to require importers to purchase allowances from a separate pool where the allowance price is aligned with the domestic ETS price—

[22] Calculated from EEA (2021) and Wiebe and Yamano (2016).

this scheme would be operationally equivalent to an import tax. Administration is a little more complex under an allowance purchase requirement than under a tax as customs officials may need to collaborate with environment ministries monitoring the ETS or a separate allowance pool.

What sectoral coverage (EITE industries or broader)?

Limiting the BCA to EITE industries, at least initially, may make sense on competitiveness, targeted leakage, administrative, and legal grounds. Competitiveness and leakage concerns are less severe for sectors like non-EITE manufacturing and services with low carbon intensity. The narrow focus also limits administrative burdens—products would need to be classified as EITE and non-EITE, but this should be straightforward given clearly specified criteria. Determining embodied carbon (with input-output tables and emissions factor data) is also relatively straightforward for the raw materials that many EITE industries produce. This narrow focus may also limit legal risks because the motivation based on leakage is more transparent and credible for EITE products than for products with low embodied carbon.

A broader BCA would more comprehensively address competitiveness and leakage and provide stronger incentives for carbon pricing elsewhere—but its near-term administrative practicality is questionable. Extending the BCA coverage to include charges on imported non-EITE manufacturing, services, mining, and perhaps electricity, combined with corresponding export rebates, would address competitiveness and leakage issues for a broader range of sectors, though these benefits may be small where carbon intensities are low. Incentives to shift "carbon imports" further down the production chain would be avoided, and charges collected from trading partner imports would also be larger. The biggest question about broad BCAs, however, is their practicality. Besides the additional administrative and compliance burdens of collecting charges on a much broader range of sectors, there are also considerable challenges to measuring embodied carbon, for example for services, and high value manufacturing products.[24]

How to measure embodied carbon?

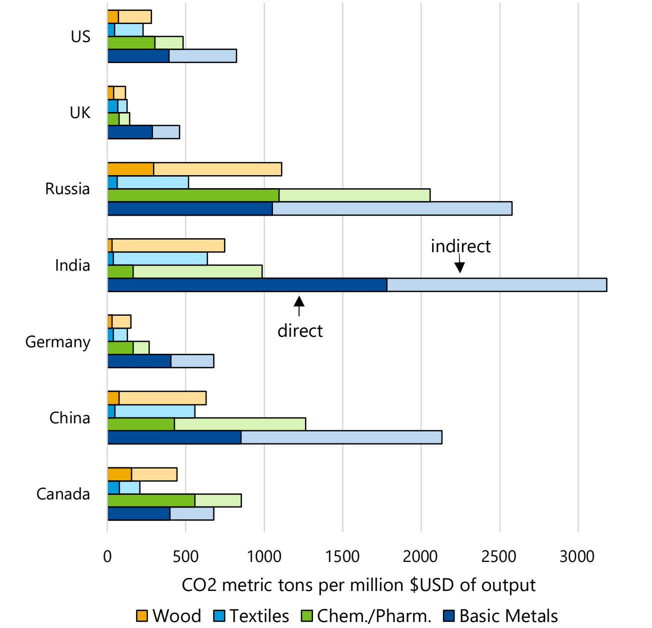
Country-specific benchmarks for embodied carbon in particular products would most directly address the objectives of BCAs. Using emissions-intensity data specific to the foreign exporting country addresses the three main rationales for BCAs: it preserves the relative costs of equivalent domestic and foreign products despite carbon pricing; trading partners for whom leakage risks are greater (due to higher embodied carbon) are accordingly subject to higher charges; and foreign governments with higher emissions intensities have stronger incentives to implement carbon pricing to avoid the BCA. This differentiation is important given the dispersion in embodied carbon within

[24] See for example Marcu and others (2020), OECD (2021), Prag (2020) and Wiebe and Yamano (2016).

product groups across countries—accounting for both direct and indirect emissions is also important (Figure 10).

Using domestic emissions-intensity benchmarks would be less effective in achieving BCA objectives but may be appropriate over some transition to limit administrative complexities and formal burdens on trading partners. Use of domestic benchmarks would provide little or no incentive for foreign exporters to reduce emissions and would imply (if the benchmark is updated) that, as domestic industries incur abatement costs in response to carbon pricing, this would in turn lead to lower charges on competing imports even though their emissions may not have changed. Administration is simpler for domestic benchmarks however as it avoids the need to calculate a different set of charges for each country. Emerging market economies (EMEs) would also face much lower formal burdens if the US or EU imposed a BCA based on domestic rather than country-specific benchmarks (Figure 11). WTO concerns may also be eased given uncertainties about whether charges can vary across countries with carbon intensity. A pragmatic approach may be to use domestic embodied carbon initially (most obviously the industry average rather than that of the cleanest firms) while the BCA is being established, with a view to transitioning to country-specific BCAs over time.[25]

Figure 10. Embodied Carbon by Product and Sector, 2015



Source: IMF staff calculations based on OECD Input-Output Tables.

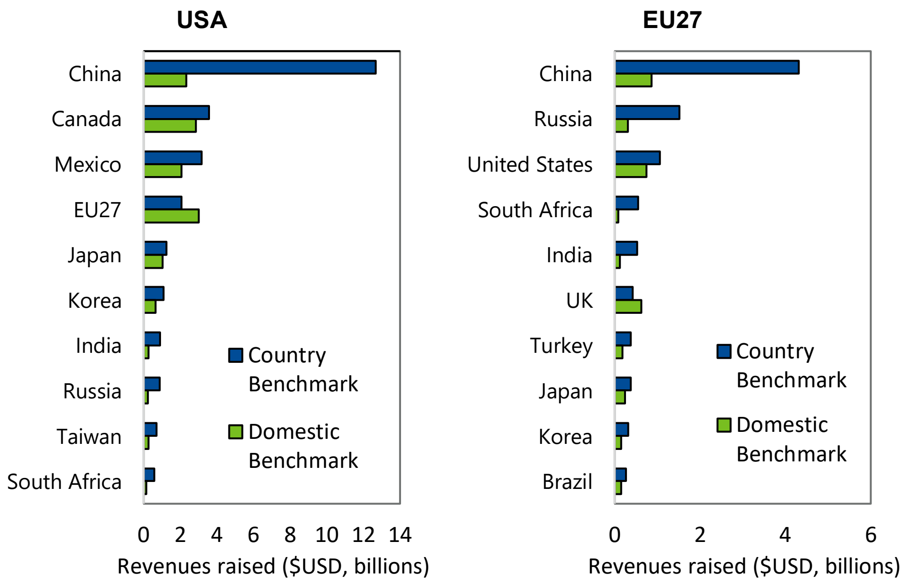
If charges vary by country, a further issue is whether to use industry-, or firm- (even plant-) level measures of embodied carbon. In principle, it would be more precise to use to use firm-level measures given the heterogeneity of production methods within many EITE industries[26] and this approach might be least likely to raise WTO concerns. It would greatly add to administrative complexity,

[25] Other possibilities include: (i) using a global average emission benchmarks, which could be a middle ground between the two extremes of domestic and foreign benchmarking; and (ii) using foreign emissions intensities, but varying the carbon price in the BCA according to development status (to respect "common but differentiated responsibilities" as per the ICPF proposal, see Parry and others, 2021). However, both may raise their own legal issues.

[26] For example, in steel production there are a variety of traditional (e.g., using coal combustion) and emerging (e.g., using coal gasification) technologies with very different emissions intensities (e.g., van Ruijven and others 2016).

however, and consistent data on embodied carbon by firm, product, and country would need to be developed and approved. For now, using industry-level data may be the more practical approach.

Figure 11. Potential Revenues from Border Carbon Adjustments on Energy-Intensive, Trade-Exposed Imports with $50 Carbon Price, 2015



Source: IMF staff estimates using Organisation for Economic Co-operation and Development (2020).

A 'rebuttability' provision allowing individual firms to claim rebates on the basis that their embodied carbon is lower than this average (subject to third-party verification or risk of audit), should improve WTO compatibility (Annex 5). There could be a risk of gaming, however, if the BCA induces firms to switch production from their cleaner plants for export to the BCA-imposing jurisdiction while redirecting products from their dirtier plants to other countries.

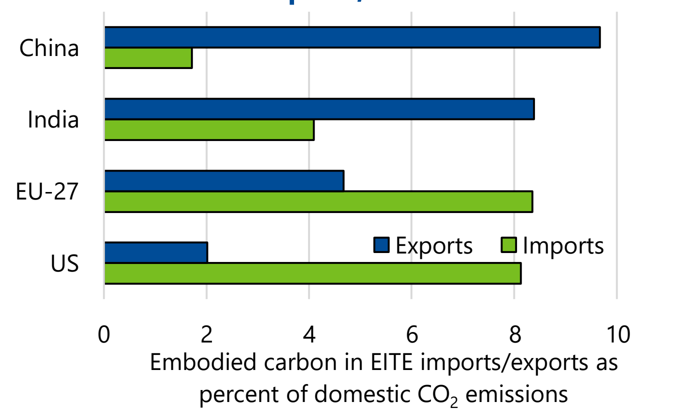
Rebates for domestic exporters?

Rebates for domestic carbon pricing on embodied carbon in domestic exports[27] are in principle warranted on competitiveness, and potentially on environmental, grounds. Rebates offset the increase in cost of domestic exports relative to foreign products caused by domestic carbon pricing—this preserves the competitiveness of the average exporter and limits leakage (as discussed in Section 2 and Annex 2, leakage is symmetric across imports and exports). Indeed, preserving export competitiveness may reduce global emissions if the emissions-intensity of production is lower at home

[27] Analogous, in economic effect, to the zero-rating of exports under the VAT.

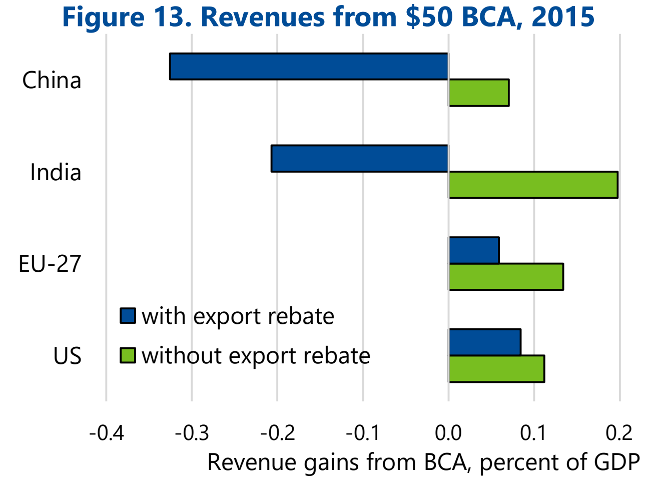
than abroad. Rebates would vary strongly across countries—for example, embodied carbon in EITE exports is 10 percent of domestic emissions in China and 8 percent in India, though only 2 percent for the US (Figure 12). Rebates should be based on firms' overall production, or industry-wide benchmarks, to avoid incentives for using more emissions-intensive production for export.

Figure 12. Embodied Carbon in EITE Imports and Exports, 2015



Source: OECD (2021).

Figure 13. Revenues from $50 BCA, 2015



Source: OECD (2021).

Export rebates reduce BCA revenues in themselves, but from a broader perspective are likely to enable higher carbon pricing and revenue. A $50 per ton BCA on imports would have raised revenues from import charges of around 0.1-0.2 percent of GDP in China, India, EU-27, and US in 2015 (Figure 13). Export rebates would offset 25 and 60 percent of the revenues from import charges on EITE products in the US and EU-27 respectively—while in China and India revenue losses from export rebates would substantially outweigh revenues from import charges (Figure 13). These effects are minor, however, compared to the overall revenue gain from comprehensive pricing of domestic carbon emissions—indeed carefully designed export rebates may help pave the way for more ambitious domestic carbon pricing and, hence, revenue.

What use to make of the revenue?

Such revenue as is raised by a BCA might be used in ways that reduce legal risks by increasing the likelihood of its being considered as an environmental (rather than protectionist) measure. Legal risk might be reduced if revenues are earmarked for green investment, just transitions, or international climate finance—though the usual difficulties of ensuring true additionality of earmarked funds, and of earmarking more generally, will apply.

How to adjust import charges for carbon pricing or other mitigation efforts abroad?

The interaction of a BCA with carbon pricing abroad involves balancing key economic, environmental, and legal issues. The measures needed to achieve the central objective of equating the domestic treatment of imports with that of domestic production depend on whether or not the exporting country rebates whatever tax it charges its own producers. If it does not rebate, then there is a clear case for reducing the carbon price charged in the BCA by the amount of carbon pricing in the exporting jurisdiction. If the foreign country does rebate—perhaps as part of its own BCA arrangement—then all that is needed is to charge the full domestic tax upon import.[29] From a wider political or environmental point of view, it may also seem appropriate to exempt from a BCA exporting countries that have "done enough" to meet mitigation goals under the Paris Agreement—even if that means lower carbon pricing than in the domestic economy (or non-price mitigation methods). There is no single "best" approach here, but some considerations follow.

Lowering the BCA rate for imports from a country with carbon pricing but no rebating on exports seems appropriate for competitiveness and leakage, as discussed above, but is subject to data requirements and legal questions. Charges on embodied emissions in EITE products will largely depend on prices for industry and power sector emissions—pricing for residential and transport fuels have little relevance for production costs for EITE industries. Up-to-date details on carbon pricing for the power and industry sectors are widely available[31] and historically fuels in these sectors were largely untaxed, or subject to minimal excises in terms of CO_2 equivalent taxes.[32] But adjustments would be needed if foreign firms are subject to emissions pricing but receive free allocations. Conventions might also be needed to account for volatility in exchange rates and in overseas emissions prices. Legally it may be difficult to justify why and how the BCA rate is differentiated across countries.

An alternative approach would be for trading partners both using carbon pricing to each maintain separate BCAs with export rebating.[33] This would follow the model for border adjustment used for VAT. In economic terms this approach is similar to the case when the BCA-imposing jurisdiction adjusts the charge for carbon-pricing but is more straightforward legally and administratively.[34] It also accommodates the case where the foreign country imposes a higher carbon

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[29] One issue that arises under the former approach is how to deal with the 'excess credit' case in which the foreign carbon tax exceeds the domestic.

[31] For example, many ETSs are limited to these sectors. See WBG (2021).

[32] See IMF (2019b), pp. 91-93, OECD (2019).

[33] This approach is recommended, for example, in Flannery and others (2020).

[34] However, one issue is that some industries might be classified as EITE in one country but not in a trading partner. This could be a problem with separate schemes with export rebates: a good not covered by a BCA would get no rebate on carbon tax paid when leaving one country but would still be subject to BCA entering the other country, implying double taxation. This could suggest a need to agree a common list of identified EITE industries across countries.

price than the domestic jurisdiction and depends less on international cooperation.

Adjustments or exemptions to a BCA to recognize other countries' mitigation efforts raise conflicting issues. The Paris Agreement embodies the concept of "common but differentiated responsibilities", which can imply lower carbon prices are needed for EMEs compared to advanced countries. Or countries might meet their Paris commitments using non-pricing instruments. In either case, exemptions from a BCA could be justified from the perspective of international environmental cooperation, and potentially from a leakage perspective (if Paris commitments are regarded as binding in levels terms on both sides, as per discussion in Section 2.B above). On the other hand, such exemptions would generally not be warranted from a narrow EITE competitiveness perspective, since lower carbon prices, or non-price measures, generally impose lower private costs on foreign exports than on domestic production. And the legal justifications for adjustments or exemptions based on interpretations of trading partners' price and non-price mitigation policies might be questioned from a WTO perspective of non-discrimination.

Exemptions for least development countries?

Applying a lower BCA rate for exporters in least developed countries (LDCs) would make LDC exporters more competitive (relative to applying a full BCA to them) with little at stake for BCA-implementing countries, and might be WTO compatible. Excluding LDCs would, in a blunt way, be consistent with the principles of equity and common but differentiated responsibilities, and it may be consistent with the WTO's Enabling Clause, if the exemption criteria are based on objective development indicators (Annex 5). Country-based exemptions would need to be designed to prevent the trans-shipment of goods from covered countries through exempted countries, requiring rules of origin; while these might well prove burdensome, they may nonetheless be warranted.[35]

4. BCAs versus Alternative Instruments

The strength of any case for BCAs also depends on the potential for addressing the multiple objectives above through other instruments. These other instruments—see Table 2 on what some countries are currently using—might include:

- Exempting all, or some, of the emissions from EITE industries from carbon pricing (in a downstream pricing program), as in South Africa, or rebating them for carbon prices implicit in fuel and electricity inputs (in an upstream pricing program);

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[35] Such regimes are in place for most regional trade agreements as part of their rules-of-origin requirements. See www.wto.org/english/tratop_e/roi_e/roi_info_e.htm.

- Allowing EITE industries to participate in a tradable emissions rate standard (i.e., where firms can fall short of the standard if they buy credits from firms exceeding the standard) in lieu of carbon pricing, as in Canada, which is another way of limiting charges on firms' remaining emissions after they meet the standard;

- Granting free allowance allocations related to industry benchmarks and past emissions for relatively clean producers for EITE industries (under an ETS) which are cancelled if firms shut down or move abroad, as in California, the EU, Korea, and New Zealand. While these are effectively lump sum payments with no immediate impact on current direct emissions, they do impact profitability in a way that dulls the incentive to relocate abroad.

Table 2. Assistance Measures for EITE Industries in Selected Countries/Regions with Carbon Pricing

Country/region with carbon pricing	Assistance Measure
Canada	A tradable emission rate scheme.
California	Free allowances under the ETS. BCA applies to imported electricity.
EU	Free allowances under the ETS but planning transition to BCA.
Korea	Free allowances under the ETS to qualifying EITE industries.
Netherlands	Levy on emissions above bechmark level (based on relatively clean firms)
New Zealand	EITE facilities receive free allowances of 60-90 percent of the industry benchmark.
South Africa	Exemptions for the first 70 percent of emissions from the carbon tax.

Source: WBG (2021).
Note: Free allowances are typically based on firms' historical production and industry benchmarks for emission rates based on relatively clean producers.

This is not an exhaustive list, but other possibilities have approximately equivalent effects to one of the above instruments. For example, feebates [36] or returning the revenues from carbon pricing collected from EITE industries in output-based rebates to those industries, are both broadly equivalent

[36] Feebates apply a sliding scale of fees/rebates on products with above/below average emission rates (see IMF 2019a, Annexes 1.4 and 1.5).

to the tradable emission rate standard (all three approaches encourage EITE industries to reduce their emissions per unit of output but, to an approximation, not to reduce their level of output). Table 3 summarizes how different instruments perform against the key metrics of concern to policymakers.[37]

Table 3. The Choice of BCAs versus Other Instruments

Metric	BCAs	Exemptions for EITE industry emissions from pricing	Tradable emission rate standard	Free allowances under ETS
Protecting competitiveness of EITE industries	Yes	Full exemption is less effective (if it does not apply to indirect emissions)	Partially	Partially
Limiting leakage	Yes (though less effective with domestic industry benchmarks)	Full exemption is less effective (if it does not apply to indirect emissions)	Partially	Partially
Promoting mitigation and carbon pricing in other countries	Modest incentive	No incentive	No incentive	No incentive
Mitigation incentives for domestic EITE industries	Yes	Full exemption remove incentives for direct (but not indirect) emissions	Reduces emissions per unit of output	Maintains all incentives
Revenue implications	Preserves revenue from pricing domestic emissions[a]	Forgoes revenue	Forgoes revenue	Forgoes revenue
Administrative burden	Significant if coverage beyond EITE products	Modest	Modest	Modest
Risk of legal challenge under WTO	Depends on design features	na	na	Could be challenged as subsidy but has not been

Source: IMF staff.
Note. [a]The BCA itself raises additional revenue (unless forgone revenue from export rebates exceeds collections from import charges).

BCAs are potentially more effective than other instruments in addressing competitiveness and leakage. This is especially the case if the BCA varies across trading partners according to embodied carbon and includes export rebates (see above). Exemptions for EITE industries from carbon pricing would be less effective unless they also included compensation for charges on indirect emissions (and import prices would not vary across countries depending on emissions intensity). Tradable emissions

[37] For further discussion of instrument choice issues see Fischer and others (2015). There may be some transitory overlap between instruments, for example, if BCAs are introduced before free allowance allocations in a domestic ETS are fully phased out. In this case, the BCA charge on foreign exports should apply to embodied carbon net of emissions that would have received free allowances under the domestic ETS.

standards and free allowance allocation under ETSs are partially effective. In both cases firms are not charged for (a large portion) of their direct emissions that remain after they have complied with the regulation, but they are charged for indirect emissions and they incur abatement costs. Indeed, the effectiveness of these instruments, relative to that of a BCA based on foreign carbon content, will progressively decline with deeper decarbonization, as efficiency costs become more significant in relation to transfers (see Section 2).

To varying degrees, most other instruments also reduce mitigation incentives for domestic industries, and they forgo revenue. Full exemptions and free allowance independent of current emissions remove mitigation incentives, at least for direct emissions; and tradable performance standards promote reductions in the emissions intensity of production but do little to reduce output levels of emissions-intensive products. Other instruments forgo revenues that could be collected from pricing domestic industry emissions (exemptions, emission rate standards, allocating allowances for free instead of auctioning them).

Administrative and legal concerns are less relevant for other instruments, however. They have relatively modest administrative burdens as they largely build off existing capacity. And they have faced no legal challenges to date (even though free allowance allocations might be interpreted as a subsidy under WTO law).

6. Conclusions

In principle, BCAs have appeal over other instruments for addressing competitiveness and leakage—and this appeal will likely rise over time with greater decarbonization—but the devil is in the details. If BCAs are related to country-specific measures of embodied carbon they neutralize the effects of carbon pricing on the relative costs of domestic and foreign products with equivalent emissions intensity. Nevertheless, it may be advisable, initially at least, to benchmark against domestic industry embodied carbon, for administrative simplicity and to ease the transition for emissions-intensive trading partners, and to consider transitioning later to country-specific measures. Limiting BCAs to EITE industries should help moderate compliance costs and might increase their credibility as a measure to target leakage—indeed from a WTO perspective the motivation and design of a BCA in legislation should be based on environmental, rather than protectionist or revenue raising, considerations. Allowing foreign firms to "rebut" industry-level assessments with third-party certifications on their individual emissions intensity should also help in this regard.

The key global challenge over the coming decade, however, is to rapidly scale up mitigation among large emitters, and BCAs by themselves provide only limited incentives in this regard. BCAs covering only a minor fraction of trading partners' emissions and imposed unilaterally by multiple countries could result in significant international price dispersion. Moreover, BCA simply frees countries to set their carbon prices in line with national objectives, without fear of adverse cross-border effects—

it thereby attenuates the free-rider problem, but (since damage from emissions related to its consumption accrues outside its borders) it does not remove it. In contrast, an ICPF could have more comprehensive coverage of emissions, and prices would be coordinated and ramped up progressively, over time, to encourage the ambition needed to address the common global challenge.

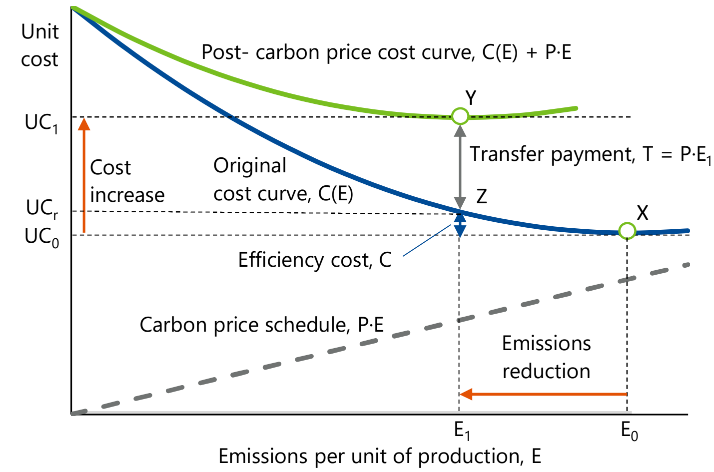
The scale of competitiveness and leakage effects may not be large enough to warrant the administrative, political, and legal complexities of implementing a BCA (compared to alternative instruments) in the early stages of carbon pricing, but pressure for BCAs will rise as regions and countries adopt more ambitious emissions pricing. If BCAs do begin to emerge on a unilateral basis this may increase interest in the possibility of formal price coordination mechanisms—which may well hold the key to effective and efficient mitigation of climate change.

Annex 1. Cost Increases for EITE Industries under Carbon Pricing vs. Non-Pricing Measures

Part A: Graphical Treatment

Figure 1.1 recalls the domestic cost increase due to carbon pricing, at a moderate level of emissions reduction. From a competitiveness perspective, if a foreign firm with the same cost structure but facing no carbon pricing continues to produce at X, a BCA on the foreign firm's emissions could be justified to level the playing field. Now suppose domestic or foreign firms are instead subject to emissions regulations.

Figure 1.1. Costs Under Moderate Carbon Pricing



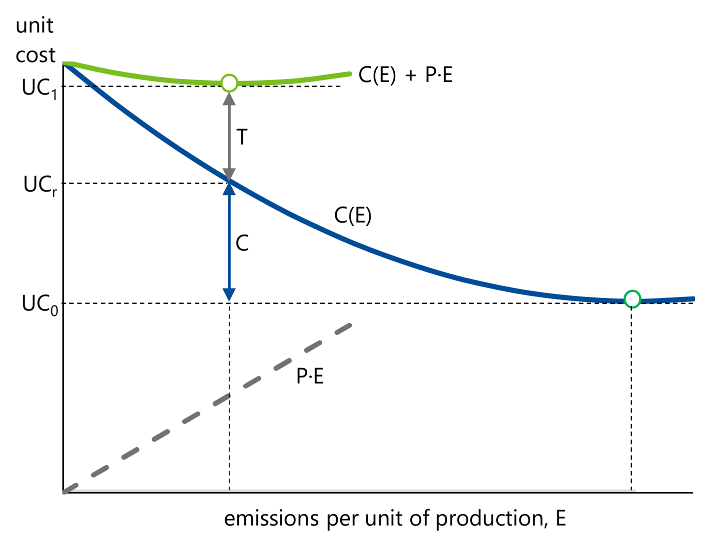
Source: IMF staff.

Case 1 – Domestic firm subject to regulations

First, consider the case when the domestic firm is subject to regulations achieving the same emissions reduction per unit of production as the carbon price. The firm's cost curve remains unchanged, so the production process moves back from X to Z. Costs increase only by C, to UC_r. Thus, although the regulation imposes the same "shadow price" of P on emissions, the private cost increase is much less than under actual carbon pricing, especially for the moderate emissions reduction shown in Figure 1.1. A BCA based on the emissions content of imports would impose much higher costs on the foreign firm than faced by the domestic firm, which would likely raise legal issues, as well as granting the domestic firm a competitive advantage.

The situation is somewhat different under much more ambitious emissions reductions, as shown in Figure 1.2. Here the efficiency cost C can become very significant (and as shown in the chart, could become comparable in magnitude to the additional transfer payment T that would apply under carbon pricing). So, in the regulations-only scenario, the domestic firm could suffer a more significant competitive

Figure 1.2. Costs Under High Carbon Pricing



Source: IMF staff.

disadvantage. However, a BCA based on the foreign firm's emissions would still not be justified, because it would not be directly related to the actual competitiveness loss suffered. In principle, an import charge related to estimates of C might be applied, but this could be difficult to gauge, being unobserved (unlike T). The consistency of such a solution with WTO rules would likely remain an issue.

Case 2 – Foreign firm subject to regulations

Now consider the situation where the domestic firm faces carbon pricing while the foreign firm faces equivalent emissions control via regulation, so both operate at the same emissions intensity. The arguments above suggest that—especially at moderate abatement levels—the foreign firm would still enjoy a cost advantage (the difference between UC_1 and UC_r), so exempting it from the BCA would not be warranted on competitiveness grounds.

From an environmental perspective, the domestic cost disadvantage (in the absence of a BCA) would still tend to result in carbon leakage, but the scale of the leakage would be limited by the action of the regulations in keeping foreign emissions intensity at the same level as the domestic firm's (as discussed in the main text, Section 2). So, while the competitiveness motivation for a BCA may be less affected by the foreign regulations, the environmental motivation for it is likely to be more significantly diminished.

Part B: Algebraic Treatment

For the home country, unit production costs are $C(E) + P.E$, where E denotes emissions per unit output, P is the domestic carbon price and unit costs C are assumed convex in E. Emissions may be set by regulatory fiat or chosen freely to minimize costs, in the latter case satisfying the necessary condition $-C'(E) = P$. Analogously, unit costs of the foreign producer selling into the domestic market are $C^*(E^*) + P^*E^*$.[40] As suggested in the text, the view might be taken that in 'levelling the playing field' one would not want to adjust for differences in costs that would arise even at common levels of emissions. That dictates benchmarking by some common technology Taking this (as suggested, pragmatically, in the text) to be that at home, equating the deemed unit costs of serving the domestic market across domestic and foreign producers requires setting a charge τ, per unit of the product,[41] such that $C(E) + P.E = \tau + C(E^*) \quad + P^*E^*$, and hence

$$\tau \;=\; (P - P^*).E^* \;+\; \{C(E) - C(E^*) - P.(E^* - E)\} \qquad \text{(A1.1)}$$

The first term on the right of (A1.1) is a 'traditional' BCA: a charge on foreign emissions at a rate equal to the excess of the domestic carbon price over the foreign. The second term adds an additional charge

[40] If the foreign country rebates carbon charges on its exports, $P^* = 0$.

[41] The analysis on the export side is symmetric, with $\tau > 0$ then corresponding to an export subsidy.

to the extent that any cost saving from (say) higher emissions abroad exceeds the consequent increase in domestic tax payable at import.

If, for example, the home country uses only regulation (so $P = 0$), then the import charge implied by (A1.1) is

$$\tau = -P^*E^* + \{C(E) - C(E^*)\} \tag{A1.2}$$

and so is positive only if domestic regulation is tight enough to lead to higher costs at home than abroad (so that $E < E^*$), and also offsets any tax levied abroad (assuming this is not removed by BCA abroad). To a first order approximation, the cost differential term is $S.(E^* - E)$, where $S \equiv -C'(E)$ is the shadow price of domestic emissions: and so this component of the tax can be thought of imposing a charge, at the domestic shadow price, on the excess of foreign over domestic emissions.

If, on the other hand, the home country deploys a carbon tax, so that $-C'(E) = P$, then to a first order approximation the second term in (A1.1) is zero, and all that remains is the traditional BCA: that is, $\tau \approx (P - P^*)E^*$.[42] More generally, the traditional BCA will somewhat overstate the import charge needed to level the playing field, to an extent that increases with the price responsiveness of emissions

[42] This follows on noting that $\tau = (P - P^*)E^* - \left(\frac{1}{2}\right) C''(\bar{E})(E^* - E)^2$, for some $\bar{E} \in (E, E^*)$. The reason for this overstatement is that (taking the case in which $E^* > E$) the cost saving associated with the higher emissions level must be less than the tax that would be saved at the rate which generates the lower level, otherwise those higher emissions would have been preferred when faced with that tax rate.

Annex 2: Carbon Leakage and Competitiveness

Although a loss of competitiveness and any consequent reduction in domestic production arising from carbon pricing (or other mitigation policy) is the ultimate cause of carbon leakage, the relationship between the two is complex and depends on a range of factors. This annex examines some of the interactions between these two concepts and shows that the competitiveness and leakage motivations for a BCA may only be loosely linked.

Leakage is defined as

$$L \equiv -\frac{\Delta E^*}{\Delta E} \ , \qquad \text{(A2.1)}Y$$

where E and E^* are domestic and foreign CO_2 emissions of the EITE industry. Writing domestic emissions as $E = eY$, where e denotes emissions intensity, the change in domestic emissions in response to the imposition or increase of a domestic carbon price is approximately.

$$\Delta E = \Delta(e \cdot Y) \approx e\, \Delta Y + Y \cdot \Delta e \ . \qquad \text{(A2.2)}$$

where Δe can be assumed negative. Production abroad, Y^* is assumed to increase by exactly the same amount as the net exports of the home country, *NX*, fall. Since $NX = Y - D$, where D denotes domestic demand, and with foreign emissions intensity unchanged, the change in emissions abroad is

$$\Delta E^* = -e^* \cdot \Delta NX = -e^*(\Delta Y - \Delta D) \qquad \text{(A2.3)}$$

Substituting (A2.2) and (A2.3) into (A2.1) gives, after some rearrangement,

$$L \approx \left(\frac{e^*}{e}\right)\left(\hat{Y} - \hat{D}\left(\frac{D}{Y}\right)\right)/(\hat{Y} + \hat{e}) \qquad (A2.4)$$

(+) (-) (-) (-) (-)

where ˆ denotes percent change, with expected signs of terms shown in parentheses. We assume $\hat{Y}$ and $\hat{e}$ are both strictly negative.

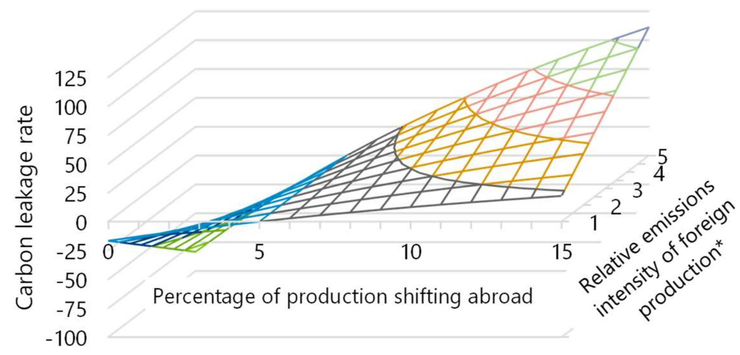
A few observations:

- Leakage is symmetric in exports and imports: (A2.4) applies whether considering an increase in imports due to loss of competitiveness, a reduction in exports, or both.
- Leakage is proportional to the original relative emissions intensity of foreign production
- Leakage is positive if home's net exports fall; it can in principle be negative, but only in the unlikely case that domestic falls by even more than domestic production.
- If emissions intensity abroad exceeds that at home by a large enough margin, leakage can be over 100 percent—meaning that total emissions increase.

Equation (A2.4) allows us to examine the influence of different factors on the leakage rate. Figure 7 in the main text showed the simplest case, with no domestic demand decline. Figure 2.1 introduces an illustrative 5 percent decline in domestic demand, in a scenario with half of local demand met by domestic production and half by (net) imports. The horizontal axis shows the change in the share of demand met by domestic production. The chart illustrates the wide range of possible leakage outcomes, including negative in the (probably very unlikely) case that the shift of production abroad is not large enough to prevent imports falling and over 100 percent when the relative intensity of foreign emissions is very high.

Figure 2.1. EITE Leakage Rates with Demand Effects

Illustrative assumption s	Carbon pricing causes 25 percent emissions intensity reduction. Price increase causes 5 percent demand reduction. 50 percent of demand met by domestic production initially.



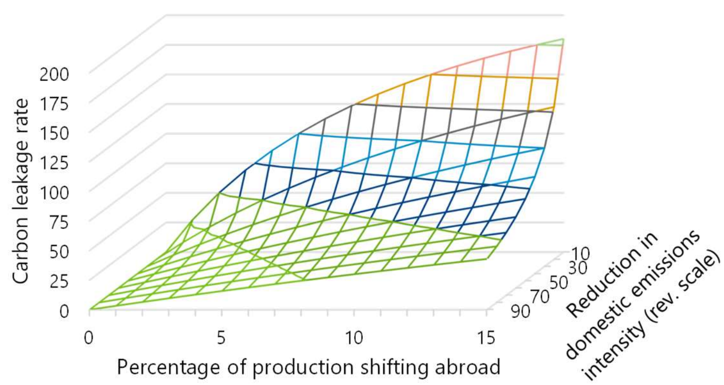
*compared to pre-carbon pricing domestic intensity

Source: IMF staff calculations.

Figure 2.2 shows how leakage can vary according to the scale of the domestic emissions cut (with scale reversed for readability). For low emissions reductions, leakage can be high even with only a small shift of production abroad. The intuition behind the lower leakage for higher domestic emissions cuts (at a given shift of production) is simply that the numerator (increase in foreign emissions) stays the same while the denominator (decrease in domestic emissions) increases. Of course, in practice a larger emissions reduction will be associated with a larger production shift, making its final effect on leakage ambiguous.

Figure 2.2. EITE Leakage Rates by Emissions Reduction

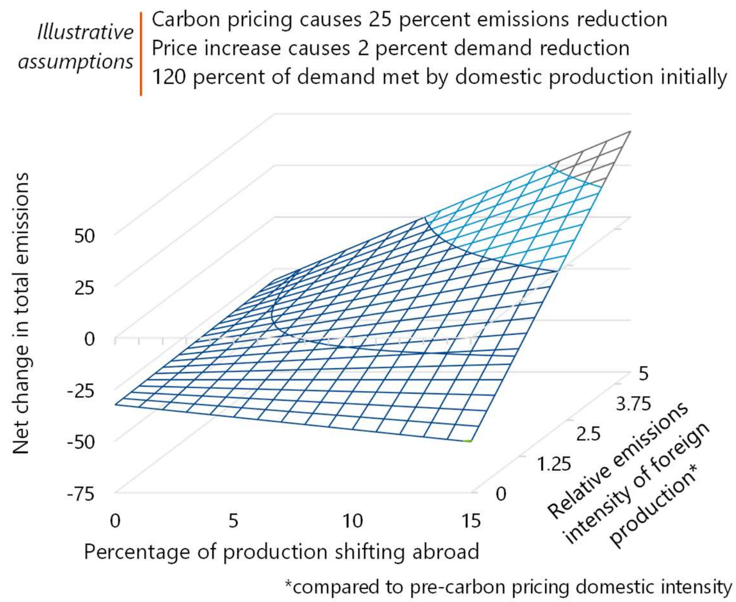
Illustrative assumptions	No demand effects Foreign emissions intensity 3 times original domestic intensity



Source: IMF staff calculations.

The extent to which carbon leakage necessarily increases total emissions is not straightforward either. If production abroad still has lower emissions intensity than the domestic industry after carbon pricing (for example, if the foreign country has abundant hydro or nuclear power), then any shift of production will still count as leakage (since foreign emissions rise while domestic emissions fall) but would result in a reduction of total emissions – over and above the fall in domestic emissions due to the carbon pricing. Figure 2.3 gives an example: at low foreign emissions intensity, the change in total emissions becomes more negative as production shifts, but it rises when foreign emissions are much dirtier. A reading above zero on this chart corresponds to a leakage rate above 100 percent.

Figure 2.3. Total Net Emissions Charge



Source: IMF staff.

The final question is how all these changes in industry emissions translate into an actual effect on total global emissions. This depends on the overall climate policies of the countries concerned. The table below summarizes the relation between changes in emissions due to leakage, and the countries' respective overall emissions policies and commitments. If a country has a firm cap on its emissions path in levels terms, which is binding over a long horizon, then in theory changes in a single industry's emissions would be fully offset by changes elsewhere in the economy. But while virtually all countries have made pledges under the Paris Agreement, in many cases they are either not binding, or set in relation to GDP, in which case changes due to leakage would still carry through to their overall emissions. Table 2.1 examines the set of possible outcomes from this perspective.

Table 2.1 Leakage and Paris commitments

Does the country have a binding long-term cap on overall CO_2 emissions in levels terms?		Foreign country (no change in mitigation policy)	
		Yes	*No*
Domestic country (imposing carbon price)	*Yes*	Leakage does not affect global emissions	Leakage "doubly" increases global emissions (foreign emissions rise but domestic do not fall)
	No	Leakage reduces global emissions (domestic emissions fall but foreign do not rise)	Leakage increases* global emissions (domestic emissions fall and foreign rise)

* Except for the case mentioned in the text that foreign emissions intensity is lower than domestic intensity after carbon pricing, in which case leakage will reduce global emissions here. Leakage is assumed to be positive for this table.

Annex 3. Empirical Literature on Emissions Leakage: A Quick Summary

A large empirical literature has estimated leakage rates, mostly for large countries or broad groups of advanced countries implementing carbon pricing, at around 10-30 percent—but reflecting leakage from both changes in the international location of production and in international fuel prices.[43] This literature largely relies on ex ante analyses using computable general equilibrium models that combine estimates of the impacts of carbon pricing on industrial production costs and assumptions about the degree of substitution between goods produced in different countries.

Misch and Wingender (2021) take an ex post econometric approach for estimating leakage from production migration, using data on how changes in sectoral energy prices in different countries and over time affect the carbon embodied in trade flows (see results in Figure 8 above). Some other ex post studies suggest little evidence of leakage for EU climate policy[44]—instead other factors (e.g., proximity to market, transport costs, quality of the local labor force, availability of raw materials) appear to be more important determinants of production location decisions. These studies, however, look at previous periods where the EU ETS price was relatively low and EITE industries were receiving free allowance allocations (which are conditional on them remaining in the EU). Going forward, as recent increases in EU ETS prices continue, and allowance allocations become less effective at preserving the profitability of EITE industries, potential emissions leakage (in the absence of a BCA) would likely increase.[45]

Annex 4. International Carbon Price Floor (ICPF)

There are two main practical obstacles to scaling up global mitigation over the next decade under the Paris Agreement. First, there are many parties (195), negotiating over many pledges (one per party), and pledges for 2030 are difficult to compare.[46] Second, it is challenging for countries to scale up mitigation unilaterally due to concerns about competitiveness and that trading partners will free ride and renege on their mitigation pledges. An ICPF could complement and reinforce the Paris Agreement as its two key elements seek to address both obstacles.

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[43] See, for example, Aldy (2017), Böhringer and others (2012), Branger and Quirion (2014), Burniaux and others (2013), Carbone and Rivers (2017), and Ellis and others (2019).

[44] For example, CPLC (2019), Dechezleprêtre and others (2019), and Naegele and Zaklan (2019).

[45] The EU ETS price jumped from $6 per ton in 2017 to over $70 per ton in 2021 (https://ember-climate.org/data/carbon-price-viewer). And the EU recently tightened its 2030 emission pledge from a 40 to a 55 percent reduction relative to 1990 levels.

[46] 2030 pledges currently vary in terms of: (i) target variables (e.g., emissions, emission intensity of GDP, clean energy shares); (2) nominal stringency (e.g., percent emission reductions); and (iii) baseline years against which targets apply (e.g., historical versus projected baseline emissions).

One element would be a focus on a small number of key emitting countries, the most important candidates (from a perspective of global emissions mitigation potential) being China, India, and the United States, though other participants might include the EU, UK (not least given its COP26 Presidency) and some other G20 countries. The second element would be a focus on a minimum carbon price, as this is an efficient and easily understood parameter, and simultaneous coordinated action to scale up carbon pricing would directly tackle competitiveness and free rider concerns. The focus on a price floor rather than a single common price level allows flexibility if countries need higher prices than the floor to meet their NDC pledges so the ICPF and the Paris Agreement would complement and reinforce each other.

An ICPF could be designed equitably with stricter requirements for higher income countries and/or simple and transparent (financial or technical) mechanisms to assist lower income countries. It could also be designed flexibly to accommodate differing approaches at the national level (e.g., different combinations of pricing and sector-based fiscal and regulatory incentives) so long as they achieve the equivalent emissions outcome as would have been achieved by meeting the price floor (as verified by third parties). Exempting participants from a common BCA applied to all those outside the arrangement (except low income countries) could be a mechanism to promote participation in an ICPF.[47] However, as noted in Section 3, differentiation of a BCA based on the country-of-origin of the imports may violate GATT's Most Favored Nation principle (with reliance on an Article XX defense then necessary).

[47] See Parry and others (2021) for further discussion of an ICPF.

Annex 5. Compatibility of BCAs with Trade Law: A Quick Look

In a nutshell, WTO rules allow countries (before needing to rely on exceptions) to provide rebates for indirect taxes on products that are exported (not to exceed the domestic tax paid on like products that are consumed domestically) and to apply a charge to imported products (not in excess of the indirect tax on like domestic products). In this sense, the WTO rules permit BCAs that are non-discriminatory harmonizing measures. Possible channels for compatibility of BCAs with WTO rules include the following.[48]

BCAs with carbon taxes. Charges on imports accompanying a domestic carbon tax might be characterized as a 'customs duty' or a 'charge imposed on or in connection with importation' under GATT Article II:2(a) which allows import charges equivalent to domestic taxes. The BCA must however be imposed on a specific product or input to that product—it is not entirely clear whether this allows for the taxing of embodied carbon which might be interpreted as a by-product rather than an input. Moreover, according to Article III:2, the BCA could not exceed the tax rate on 'like' domestic products, raising some uncertainty about applying higher charges to imports with higher embodied carbon, unless the latter are interpreted as 'unlike' domestic products.

Export rebates for carbon taxes might be allowable under the WTO Agreement on Subsidies and Countervailing Measures (SCM Agreement), footnote 1, which specifies that rebates of domestic indirect taxes—in principle including energy taxes—should not be deemed export subsidies. Again however, the rebate would have to be offered on the same terms to all domestic firms covered by the carbon tax—if 'like' products are interpreted by characteristics other than embodied carbon, the no-greater-than requirement would imply the rebate could not exceed the lowest tax rate levied on domestic producers, that is, the rate assessed on the cleanest producer.

BCAs with ETSs. If a BCA requires importers to purchase allowances from a domestic ETS or separate allowance pool this would likely be considered a form of domestic regulation under GATT Article III:4, which requires that the imported product receive regulatory treatment no less favorable than the like domestic product. Again, if imports are viewed as 'like' domestic products requiring allowance purchases according to the carbon content of imports, rather than the carbon content of domestic products, this might breach WTO rules. On the other hand, a BCA on exports, taking the form of a rebate for the costs of an ETS, could be considered a prohibited export subsidy if rebates were not available for like products sold domestically—there is no provision in WTO law for border rebates of regulatory costs.

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[48] The discussion here draws from Cosbey and others (2019) and OECD (2020). See also Flannery and others (2018), Holzer (2014), Mehling and others (2019), Pauwelyn (2013), and Trachtman (2016).

Irrespective of whether the BCA accompanies a carbon tax or an ETS, Article I prohibits discrimination among imports based on their country of origin. If a BCA regime differentiates imports based on country-specific estimates of embodied carbon, rather than applying the same embodied carbon to all countries, it could violate the Most Favored Nations (MFN) principle if measures of embodied carbon were viewed as arbitrary—though allowing relatively clean individual exporters to request lower BCAs might lower the risks of measurement procedures being viewed as arbitrary. Special treatment for some countries (e.g., those meeting ambitious Paris mitigation pledges) might also violate the MFN principle, in the absence of an objective test, applicable to all. Exemptions for least developed countries might be allowed under the WTO's Enabling Clause, if the exemption criteria are based on development indicators, and countries in similar conditions are treated the same way.

Even if a BCA is found to violate other Articles, it may still be allowable under GATT Article XX (General Exceptions). This would apply if, according to sub-paragraph (a), it is necessary to protect human, animal, or plant life or health or, according to sub-paragraph (g), it relates to the conservation of exhaustible natural resources. Most analysts see sub-paragraph (g) as easier to comply with given the requirement to prove necessity in paragraph (a). In effect, any BCA must demonstrate that it is effectively addressing climate change, for example, through containing leakage. The BCA would also need to satisfy the introductory paragraph (the "chapeau") of Article XX, which requires that it not be applied in a manner that would constitute "a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail" and is not "a disguised restriction on international trade." Historically, very few measures have survived scrutiny under the chapeau, underscoring the importance of designing BCAs in a WTO compliant fashion, with the need to rely on the exceptions only as a fallback.

A BCA may fail to satisfy Article XX if it:

- Requires specific policy changes as a basis for exemption from the BCA which might constitute arbitrary discrimination under GATT's exceptions provisions because measures tied to country-level policies will punish all producers from targeted countries, regardless of their individual environmental performance—instead, the BCA should offset the differential between foreign and domestic carbon pricing;
- Assesses adjustments based on the country of origin, rather than based on objective criteria applicable to all countries, which may include emissions-related policies, or the environmental performance of individual producers;
- Implements the BCA without having tried to negotiate in good faith to reach some multilateral solution to the problem of carbon leakage (negotiations under the Paris process could arguably be considered steps in this direction);
- Allows exemptions from coverage of the BCA (e.g. for parties that have ambitious climate goals under the Paris Agreement) or for specific domestic producers that are not based on the objective of mitigating climate change by preventing leakage.

Importantly, while GATT Article XX can provide justification for breaches of GATT obligations, most analysts agree that it does not cover breaches of obligations in other WTO Agreements like SCM. For example, a BCA considered to provide a prohibited export subsidy under the SCM Agreement would have no recourse to GATT Article XX. Nonetheless, under the SCM, a carbon tax would likely be an indirect tax, and therefore export adjustments would be legal, provided that the amount of the adjustment is not more than the domestic carbon tax incurred.[49]

[49] A possible precedent for BCAs is the WTO ruling that the US tax on imported substances produced or manufactured using chemicals subject to the Superfund tax was consistent with Article II:2 (a) and the principle of national treatment (see Genasci 2008).

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