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Potential impacts and challenges of border carbon adjustments

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Harmonized carbon pricing across borders is hard to achieve in the real world as carbon leakage can reduce the cost-effectiveness of unilateral approaches to reduce global emissions. To address this problem, border carbon adjustments (BCAs) would apply the domestic carbon price to emissions embodied in traded goods, which levels the playing field for emissions-intensive and trade-exposed industries. Here, we review the potential environmental and economic impact of border carbon adjustments on leakage reduction, competitiveness restoration, cost-effectiveness, equity and cooperation enhancement. We find that the viability of border carbon adjustment schemes can be substantially reduced with the current legal and practical implementation constraints.

The fundamental challenge in climate policy is to cope with the fact that climate protection constitutes a global public good. Each country has a strong incentive to free-ride on the emissions abatement of other countries while contributing little itself. Without a supranational authority to coerce common action, a 'tragedy of the commons' arises, in which countries' self-interest prevents a globally efficient climate policy. Participation in an international climate treaty has to be voluntary and self-enforcing.

As a consequence of free-rider incentives, the voluntary commitments made by countries in the Paris Agreement are insufficient to achieve the Paris target of limiting global warming to well below 2 °C (ref. [1]).

Cost-effective climate action calls for coordinated, harmonized carbon pricing across jurisdictions worldwide to reduce carbon emissions where abatement is cheapest[2,3]. In reality, myriad uncoordinated, unilateral climate policies are leading to a landscape of divergent carbon prices with limited geographical coverage[4,5]. When carbon emissions are priced unilaterally, the global environmental impact will be undermined to the extent that international markets transmit spillover effects that increase emissions in other countries. Dubbed 'carbon leakage'[6–9], these effects occur primarily via two channels[10]. The fossil fuel market channel transmits leakage when emissions regulations in open economies reduce the demand for fossil fuels, which causes global fossil fuel prices to fall and thus stimulates demand for fossil fuels in unregulated regions. Leakage through the competitiveness channel occurs when unilaterally regulated carbon-intensive businesses reduce production because of higher operating costs, while production by less regulated manufactures abroad increases. Other potential leakage channels, such as international technology spillovers[11], are also possible but more uncertain, and thus often ignored in quantitative analyses.

Carbon leakage raises concerns about the effectiveness of unilateral climate policies. Economists worry that leakage hampers global cost-effectiveness. Representatives of emissions-intensive and trade-exposed (EITE) industries in climate-concerned nations point out that leakage results from an undue disadvantage vis-à-vis less regulated competitors abroad. Environmentalists view leakage as an avoidance mechanism—a loophole whereby consumers in developed countries substitute higher-priced domestic products of lower carbon content with imports that are cheaper but more carbon intensive.

Appeal of border carbon adjustments

To address these concerns, countries with a domestic carbon price could implement border carbon adjustment (BCA)—that is, levy a charge on the carbon embodied in imports from regions without carbon pricing. For symmetry, a rebate to exports (to unregulated regions) could offset their embodied carbon payments. Combining a domestic carbon price with BCA is similar to the treatment of value-added taxes, which apply only to goods consumed domestically, in that imports are charged with the domestic value-added tax rate, whereas exports are exempt[12]. In both cases, the adjustment has the effect of taxing consumption rather than production.

At first glance, BCA may appeal for several reasons. By capturing emissions embodied in traded goods, it can reduce leakage through the competitiveness channel and improve the global cost-effectiveness of unilateral action—the global economic cost to achieve a given reduction in global emissions. BCA creates a level playing field for Emissions Intensive Trade Exposed (EITE) industries: import adjustments mean that suppliers from countries without domestic carbon pricing also face an increase in carbon costs, so they do not gain an unfair competitive advantage when carbon prices rise. Similarly, export rebates create competitive neutrality in foreign markets. More generally, BCA can secure competitive neutrality across countries with differential carbon prices if foreign countries with some carbon pricing also adopt BCA or if the domestic unilateral adjustment mechanism covers only the difference in carbon prices. In this case, differences in carbon prices between countries do not incentivize production shifts to the country with the lower carbon price. Competitive neutrality is important from a political economy perspective. Addressing concerns about unfair competitiveness losses of EITE industries may be a prerequisite for a broader socio-economic acceptance of stringent unilateral emissions pricing. Finally, BCA marks a shift towards

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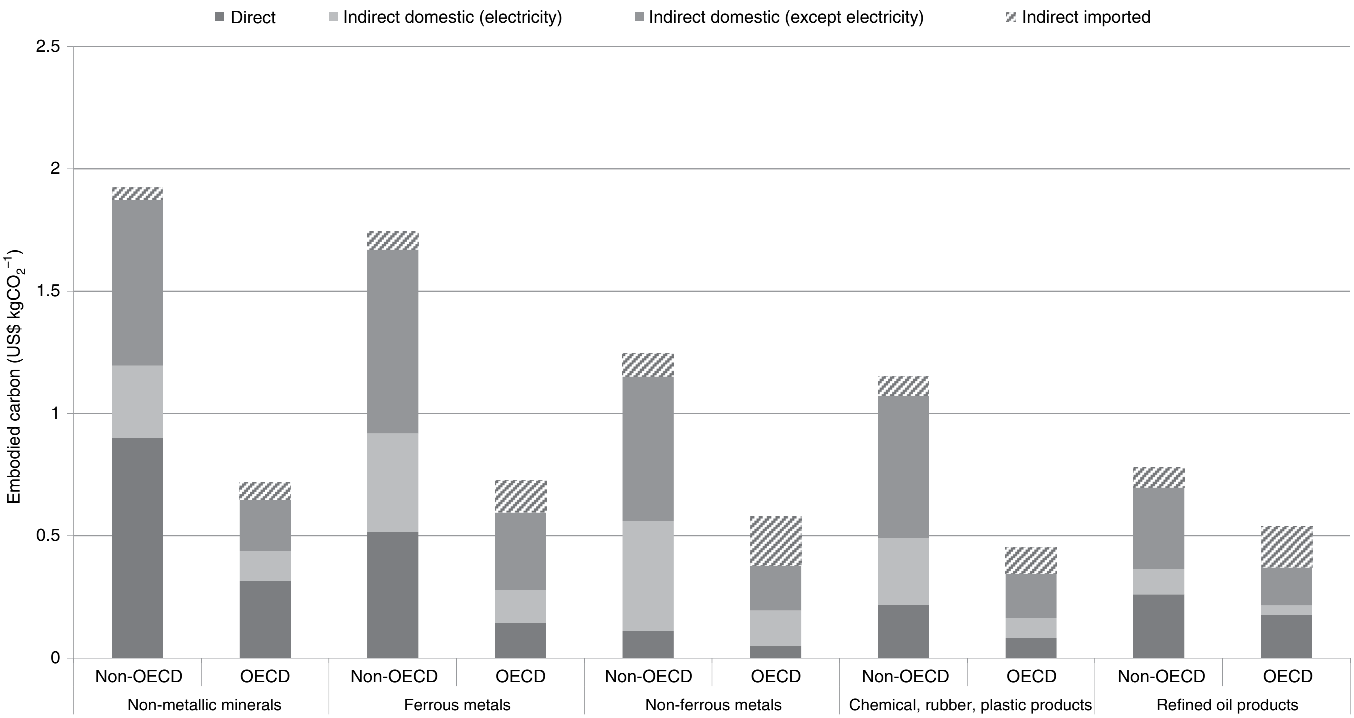

Fig. 1 | Composition of carbon content for EITE goods between OECD and non-OECD countries. The domestic carbon content is stated in kilograms of CO_2 emitted in the production of a good per dollar of output value. Total domestic carbon content is parsed into direct emissions, indirect emissions from domestic electricity generation, other indirect emissions embodied in all other domestic intermediates used in production and emissions embodied in imports. Data from ref. [87].

regulating emissions in domestic demand for which consumers are responsible.

The fundamentals of BCA have long been debated in economic theory[13–15]. In policy practice, however, BCA raises concerns about legal feasibility and practical implementation. BCA could be perceived abroad as a form of protectionism. The risk of trade conflicts largely explains the reluctance to implement border adjustments to date. Economic research reviewed in this Review Article also suggests that the gains from BCA may be limited. So far, BCAs are adopted only in California's and Quebec's cap-and-trade systems, which tax electricity imports on the basis of emissions intensity. The European Commission's recent proposal for a BCA mechanism with import charges to EITE goods regulated through its emissions trading system (ETS) may mark a turning point[16]. It is also worth noting that existing trade policies, although not directly related to climate, affect global emissions: in most countries, import tariff and non-tariff barriers are substantially lower for dirty than for clean industries, which results in an implicit global subsidy to carbon emissions in internationally traded goods[17].

Legal constraints

BCAs should pass muster with international trade law[18–20]. Members of the World Trade Organization (WTO) must respect the non-discrimination principles laid out in the General Agreement on Tariffs and Trade (GATT): most-favoured-nation treatment (GATT Article I) and national treatment (GATT Article III). Article III sets out the conditions under which countervailing measures applied to imports are permitted; the Agreement on Subsidies and Countervailing Measures governs countervailing measures applied to exports. Violations to obligations regarding the treatment of imports could be justified under GATT Article XX ('General Exceptions'), of which the most relevant are points (b) 'necessary to protect human, animal or plant life or health', and (g) 'relating to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption'. The Agreement on Subsidies and Countervailing Measures offers no such exceptions.

Notably, international law views carbon taxes as fiscal instruments, akin to indirect taxes, such as excise and value-added taxes, which are commonly border adjusted. By contrast, an ETS, which can produce equivalent carbon prices, is viewed as a regulatory instrument, for which cross-border reach is typically restricted to product- rather than process-related attributes. Consequently, the form and type of BCA allowed will depend on the form of carbon pricing. BCAs are more likely to comply with WTO law if they mirror the domestic obligations; countries need to provide imports with comparable opportunities for compliance, which include surrendering allowances, credits or offsets. Import adjustments are more likely to pass muster than rebates to exports, but import adjustments that discriminate among 'like' products or attempt to regulate foreign production may need to justify themselves based on an Article XX exception—namely, demonstrate that the measures actually increase the environmental effectiveness of unilateral emissions pricing by reducing carbon leakage. As exempting exports from domestic carbon pricing prima facie increases carbon emissions, to exempt exports from a carbon tax could be difficult to justify, and export rebates for ETS-regulated firms would most likely be disqualified as illegal subsidies under WTO law.

Practical implementation constraints

BCAs face several practical implementation challenges, leading to trade-offs between their effectiveness and compliance with WTO rules[21,22]. First, under WTO law, a country cannot make adjustments for costs that it does not impose on its own businesses, so the scope of adjustment must be consistent with the scope of domestic application (for example, the European Union (EU) ETS covers only power stations, energy-intensive industries and intra-EU aviation). Therefore, direct emissions from covered sectors can be adjusted,

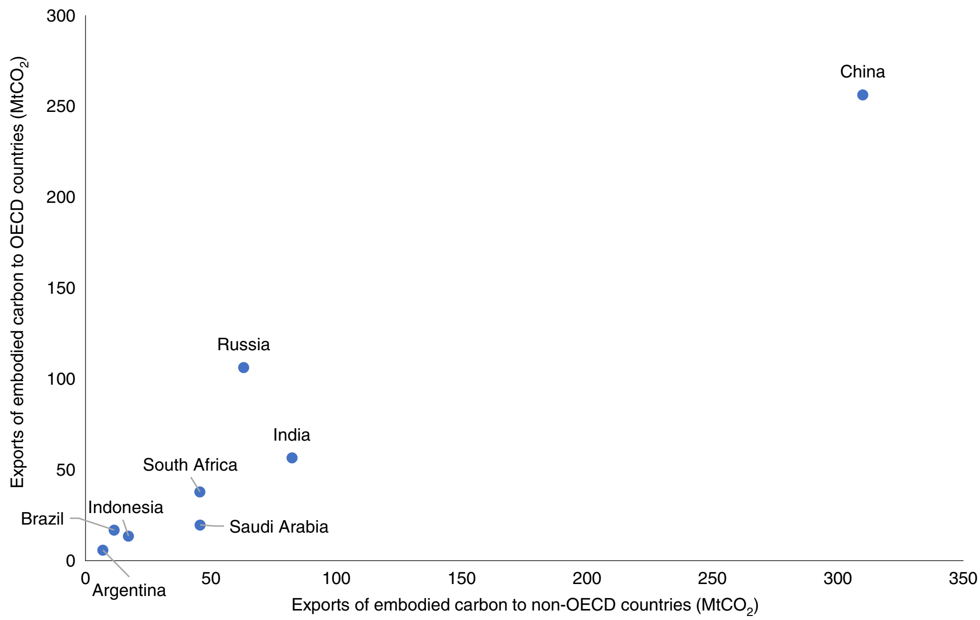

Fig. 2 | Exports of embodied carbon in EITE goods from non-OECD G20 regions to OECD and non-OECD countries. Embodied carbon is the product of emission intensities and the dollar value of export flows summed across EITE goods. Data from ref. [87].

as can indirect emissions from covered electricity (which can be substantial for electricity-intensive industries, such as aluminium smelting), but to address the carbon embodied in the supply chain (that is, carbon embodied in other intermediates used in production, such as emissions from producing primary aluminium used in the production of aluminium products) becomes more challenging.

The second challenge is calculating the embodied emissions. If a goal is to incentivize foreign producers, the amount to be paid by importers should be based on the specific carbon content of the imported good. Exporting firms will have an incentive to reduce their emissions only if doing so lowers their border charges—that is, if actual emissions are used to calculate the adjustment (presuming the default emissions rate is higher than the companies' actual emissions). However, the carbon content of goods produced in foreign jurisdictions is difficult to measure. Requiring individual data with credible third-party verification is probably achievable for direct emissions, but seems prohibitively expensive—if feasible at all—for indirect emissions, which account for the majority of embodied emissions for most EITE goods. More specific targeting and legal verification of emissions streams would lead to higher implementation costs and technical barriers to trade. As a result, a default emissions rate would most probably have to be calculated based on industry- or technology-specific average measures of embodied carbon[23,24]. Creating country-specific defaults would conflict with WTO national treatment obligations and require recourse to Article XX. The downside of a uniform metric is that import adjustments would not provide a direct incentive for individual manufacturers abroad to avoid emissions. One strategy is to allow producers to demonstrate that they are cleaner than the benchmark, which should improve compliance with WTO rules and recover some incentives. The tension is that to give companies incentives to reduce emissions also gives incentives to 'reshuffle' emissions: border charges could be avoided by simply reallocating the lowest-carbon production for export to countries with BCAs, and leave the higher-carbon production for consumption in other markets.

A third challenge is the question of which products should be eligible for adjustment. EITE industries are obviously able to make a case that a BCA will reduce leakage, but how far down the supply chains should the BCA go? For example, if you adjust steel, do you also adjust the steel tube? There is a tension between avoiding costly complexity by excluding products that have a low share of emissions in their value added and avoiding diversion of leakage through higher-value-added goods that use EITE products as inputs.

The fourth challenge is adjustments to the adjustments. To comply with WTO rules, any compensation granted to domestic producers should also be granted to foreign producers. As nearly all carbon-pricing schemes in practice provide special conditions to EITE industries—the EU ETS, for example, gives free allocation[25] and allows for financial compensation of higher electricity costs to EITE firms at risk of carbon leakage—the import adjustment would have to be reduced accordingly until the special conditions are phased out. If other countries price emissions at a different level, the import adjustment should, in theory, just offset the differential between foreign and domestic price-based climate policies. However, differences across jurisdictions in carbon-pricing scope, exemptions and free allocation make this very difficult in practice.

Emissions intensities and trade in embodied carbon

Carbon leakage through the competitiveness channel as well as the potential effects of BCA are driven by regional differences in the emissions intensities of EITE production and the pattern of international trade. Figures 1–4 illustrate these drivers based on empirical data for Organisation for Economic Co-operation and Development (OECD) and non-OECD countries from the Global Trade Analysis Project (GTAP)[26] for 2014, the most recent year of the dataset. Domestic indirect emissions account for a large share of embodied emissions and for larger differences in emissions intensities across regions (Fig. 1). Import adjustments based only on direct embodied emissions would therefore significantly underestimate the full emissions embodied in EITE goods. Indirect emissions stem largely from electricity use. Although electricity itself is not a widely traded commodity, its indirect effect on emissions embodied in trade is sizeable.

Multiplying product- and country-specific emissions intensities by bilateral export flows yields the trade patterns of carbon embodied in EITE goods between OECD and non-OECD G20 economies. Among non-OECD countries, China is by far the most important

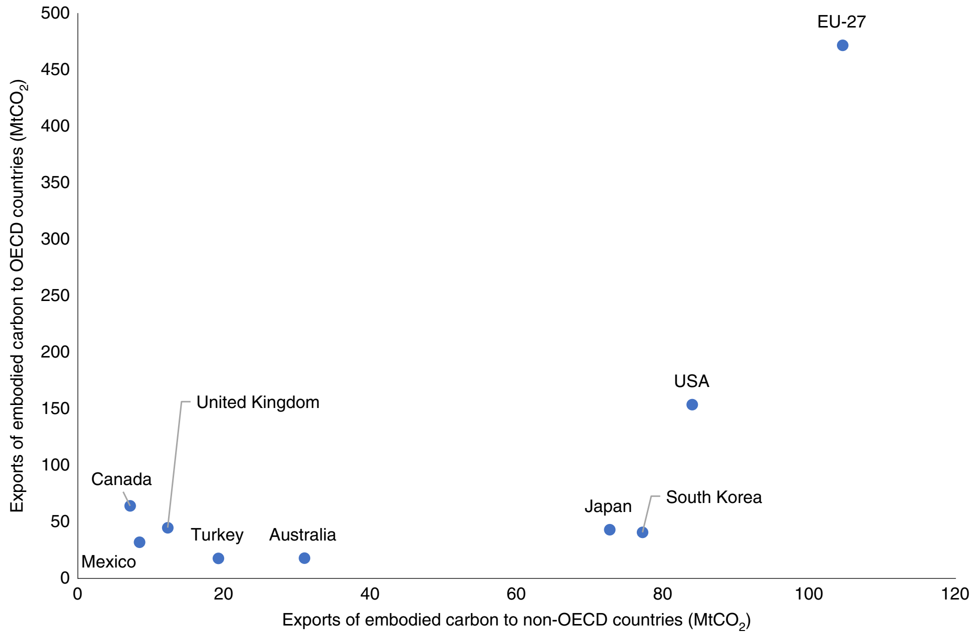

Fig. 3 | Exports of embodied carbon in EITE goods from OECD G20 regions to OECD and non-OECD countries. Embodied carbon is as defined in Fig. 2. Data from ref. [87].

target for import adjustments (Fig. 2); among OECD countries, the EU-27 stands to gain the most from export adjustments (Fig. 3).

For 2014, EITE exports of embodied carbon from non-OECD to OECD countries amount to 5.3% of all non-OECD emissions and 7.9% of all OECD (production-based) emissions, respectively.

The scatter plot in Fig. 4 compares the import share from non-OECD to OECD and the export share of OECD to non-OECD countries for EITE industries. The farther to the right (top) an EITE industry is located, the more effective an import adjustment (export rebate) should be in protecting domestic EITE production.

To summarize, trade in embodied carbon between OECD and non-OECD countries is sizeable, with carbon intensities of EITE products being much higher in non-OECD than in OECD countries. This suggests that BCAs have the potential to play an important role in addressing carbon leakage. However, much of the embodied carbon comes from indirect emissions, which indicates that the practical implementation of BCA can become quite challenging.

Leakage estimates

Leakage is typically reported in terms of leakage rates, which quantify the change in foreign emissions relative to domestic emissions reduction as a direct consequence of unilateral emissions pricing. For example, a leakage rate of 50% indicates that half of the domestic emissions reduction is offset by an increase in emissions abroad.

Leakage through the competitiveness channel will be larger the more that emissions intensities differ between trading partners (assuming lower emissions intensities in the regulating country), the more important the trade in EITE products is and the more responsive unregulated production abroad is to changes in regulated production[27]. Responsiveness is generally measured by price elasticities, which reflect not only consumer preferences but also the industrial organization (the type and degree of competition) faced by companies in domestic and international markets. Empirical estimates based on time series or cross-sectional variation in prices or costs are pivotal, but are constrained by data availability and identification problems[27–33].

Empirical evidence on leakage is scarce to date. Ex post analysis of the Kyoto Protocol suggests substantial leakage[34,35]. Econometric studies at the level of EITE industries covered by the EU ETS found little to no leakage[36–40]. These results are unsurprising given the low emissions prices, the generous free allocation of emissions allowances to EITE companies during the ETS periods studied and the short time horizons assumed, as leakage through industry relocation is likely to occur in the mid-to-long run.

To estimate leakage rates associated with stricter carbon pricing, applied economic research relies primarily on ex ante numerical simulations that facilitate controlled policy experiments. Economy-wide analyses build on multisector, multiregion computable general equilibrium (CGE) models that incorporate interindustry and international trade relations based on empirical input–output data[41,42]. Systematic CGE model cross-comparisons—such as the 29th study by the Energy Modeling Forum (EMF)[43] and subsequent meta-analyses of simulation studies[44–46]—suggest central estimates of leakage rates for industrialized countries that range from 5% to 30%, which reflects different assumptions on the stringency of carbon pricing, the size of the abatement coalition and the magnitude of trade and fossil fuel supply elasticities. The relocation of EITE industries abroad, and thus emissions leakage from domestic cost pressures, can be significantly exacerbated when EITE industries operate in imperfectly competitive markets[47–49]. Leakage estimates derived from CGE simulations include leakage through the fossil fuel market channel, which tends to dominate leakage through the competitiveness channel[9,10,43,50,51] unless the global supply of fossil fuels is very price inelastic[52,53]. The competitiveness channel is narrower than the fossil fuel market because it primarily affects EITE industries, which account for a relatively small share of the economy; leakage through the fossil fuel channel would occur even if no goods other than fossil fuels were traded internationally.

Sector-specific simulation studies focus on the competitiveness channel and incorporate more details on firm heterogeneity and market structure than economy-wide CGE analyses. They found leakage rates that range from 20% to 70% for the cement, aluminium and steel industries, which suggests that a significant portion of emissions reductions in domestic EITE production could be offset by increased emissions abroad[27,54,55].

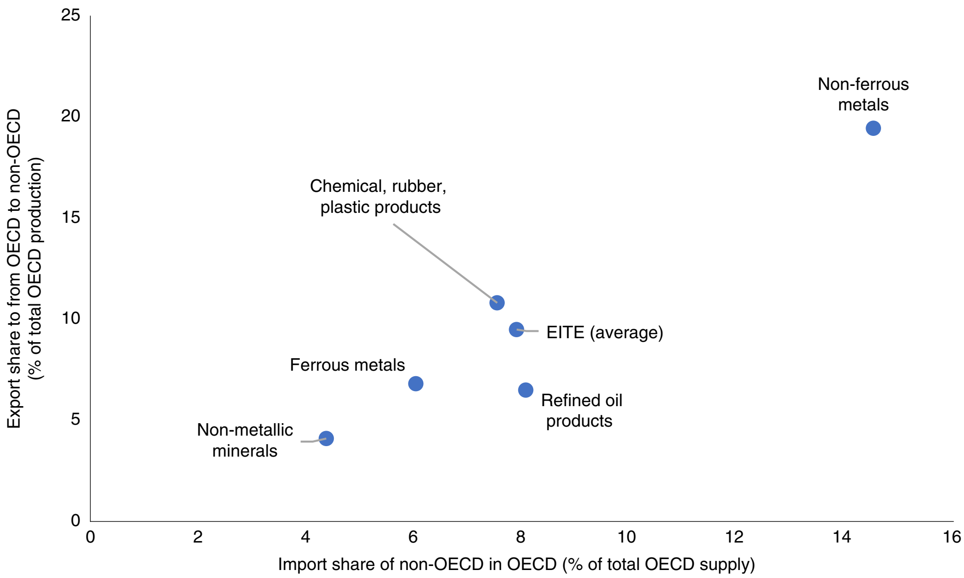

Fig. 4 | Import and export shares for EITE industries. Import shares are computed by dividing the value of the import from non-OECD to OECD countries by the value of domestic market demand in OECD. Export shares are computed by dividing the value of the export from OECD to non-OECD countries by the value of OECD production. Data from ref. [87].

Potential environmental and economic impacts of BCAs

As BCAs for EITE industries have not yet been implemented, their potential environmental and economic consequences are quantified using ex ante simulations (see, for example, refs. [43,45,53,56,57]). The review of simulation results permits a critical evaluation of BCA against four policy-relevant criteria: (1) the BCA's effectiveness in reducing leakage; (2) its ability to restore the competitiveness of EITE industries; (3) its potential to increase the global cost-effectiveness of unilateral emissions pricing; and (4) its implications for equity in the international burden sharing of climate protection. In what follows, each of these criteria is discussed in a setting in which non-regulating countries remain passive towards the implementation of BCA. Subsequently, the implications of possible reactions by these countries are discussed. It is important to keep in mind that BCAs can reduce leakage only through the competitiveness channel.

Leakage reduction. The common finding is that BCAs are effective in curbing leakage through the competitiveness channel. The aforementioned EMF 29 study[43], which considers a 20% emissions reduction in the industrialized world (countries listed in Annex 1 of the Kyoto Agreement), found that the BCAs for EITE industries reduce leakage rates by about one-third (from a mean of 12% with a BCA to a mean of 8% without). Models that looked at sector-specific leakage for EITE industries often found substantially higher levels of effectiveness[24,45,58], which also echoes an exclusive focus on leakage through the competitiveness channel. However, to the extent that studies reflect a short time horizon, the estimated leakage rates can be very low. Capital-intensive EITE industries, such as copper and aluminium, have high levels of sunk costs in existing installations, and hence the short-run responses through relocation are quite small[59].

Narrowing the scope of application and presumptive emission benchmarks in adherence to WTO obligations will limit the environmental reach of BCAs. Notably, a single benchmark for import charges based on a default emissions rate fails to reflect the heterogeneity in firm-level emissions intensities[60] and does not provide incentives at the level of foreign firms to abate emissions: the only way for foreign firms to avoid import charges is to reduce exports to countries with BCAs. The few CGE studies that consider source-specific import charges found that leakage reductions are significantly greater than those achieved with levies imposed at the industry level[61,62]. However, as these studies represent each sector with a single representative firm, the results are more indicative of industry-level than of firm-specific adjustments. Firm-specific BCAs are prone to counterproductive 'reshuffling', that is, contractual gaming: on the input side, akin to profit shifting through transfer pricing, companies could declare that their less-carbon-intensive inputs (for example, renewable energy credits) are used for the subset of their goods subject to import adjustments; on the output side, emissions-intensive output (for example, electricity from fossil fuel combustion) could be redirected to avoid carbon penalties at the border. In particular, reshuffling is a problem for electricity, for which sources of power generation are substitutable but the carbon intensities across the sources are quite heterogeneous. A recent analysis of California's greenhouse gas pricing programme predicts that differentiated BCAs to electricity imports will be ineffective in curbing carbon leakage because carbon-free resources from other states may be preferentially dispatched to California[63]. Although a more targeted approach could allow for a greater legitimacy and legality of the import charges as a supplemental instrument in unilateral climate policy, analysis that does not consider reshuffling options may significantly overstate the yield of firm-specific import adjustments with respect to leakage reduction.

Omitting export rebates from the BCA scheme tends to reduce effectiveness because rebates avoid leakage from losing EITE market shares abroad; however, for countries that are large net importers of carbon, most of the leakage mitigation comes from import adjustments[43,53].

Competitiveness. A common finding of simulation studies is that BCAs level the playing field, and thereby avoid unfair structural change to the detriment of domestic EITE industries[43,64]. Economy-wide CGE studies, which are less detailed at the industry level, report much smaller output repercussions of unilateral emissions pricing than industry-specific (sectoral) partial equilibrium studies; the latter sometimes even found that carbon pricing with BCA can lead to a greater output than in the absence of carbon pricing[45].

An important caveat relates to the role of export rebates in restoring competitiveness in foreign markets. Import adjustments alone may exacerbate rather than mitigate the negative effects of unilateral emissions pricing for EITE industries that import a large share of border-adjusted embodied carbon and export a large share of their production[65,66].

Global cost-effectiveness. BCAs can improve global cost-effectiveness by partially transferring carbon pricing via trade flows to trading partners without emissions pricing policies. As BCAs reduce carbon leakage, unilaterally acting regions can scale back the level of domestic emissions pricing required to achieve the same global emissions reduction as without the BCAs. Effectively, BCAs reduce the carbon pricing differential between regions with and without emissions pricing, which reduces efficiency losses from non-uniform carbon pricing. However, the magnitude of the efficiency gains remains limited because only a small fraction of emissions abroad (those that are imported in covered goods) can be targeted, and foreign EITE industries may also reroute part of their exports to other non-regulated markets.

Simulation studies confirm that the cost savings of a BCA, when implemented in a practical manner for EITE industries, are limited[53,64]. The EMF 29 cross-model comparison[43] concludes that the application of BCA can save up to 10% of economic adjustment costs worldwide as the industrialized world undertakes emissions pricing to reduce its emissions by 20%. Studies that look at a smaller abatement coalition and/or more ambitious abatement targets (that is, higher unilateral emissions prices) found higher cost savings, which can be traced back to higher initial leakage rates[53]. Cost savings may also increase when BCA revenues are used to reduce existing distortionary taxes[67]. If only import adjustments are implemented (and not export rebates), welfare gains are somewhat lower[53]. BCAs based on a default emissions rate as a uniform benchmark are more friendly to national treatment provisions, but at the same time lose cost-effectiveness because they do not penalize more emissions-intensive foreign production; however, the difference in effectiveness seems limited[61,62]. The fact that emissions intensities already vary widely even within industrial sectors[60] increases the risk of reshuffling, which further limits the scope for global effectiveness gains from BCAs.

Notwithstanding the ability of a BCA to increase the effectiveness of unilateral carbon pricing, it is important to keep in mind that unilateral approaches have their pitfalls, as they lack the kind of international cooperation, such as comprehensive emissions trading, that can exploit larger efficiency gains from abating emissions where they are cheapest worldwide. Unilateral emissions pricing is far from achieving a globally cost-effective outcome—with or without BCAs.

Burden shifting. The results of simulation studies indicate that import adjustments have a strong burden-shifting effect. The basic mechanism is well known from the economic theory on optimal tariffs[68]. To the extent that import prices decrease to absorb some of the incidence of carbon adjustments, exporting countries subject to BCAs will suffer a loss in export revenues, whereas importing countries benefit from an improvement in their terms of trade. Import adjustments on embodied carbon applied by richer, industrialized countries are likely to shift some of the burden of emissions pricing to poorer, developing countries[43,56,57,69–71]. This outcome may be at odds with the principle of common but differentiated responsibilities articulated in the United Nations Framework Convention on Climate Change and reaffirmed in Article 4(3) of the Paris Agreement.

Such equity concerns can be addressed by returning the revenue from carbon import adjustments to paying countries or using it for technology transfer and international climate finance. Addressing equity by exempting developing regions, however, could undermine the legitimacy of BCAs[21,72].

Clearly, the potentially regressive nature of BCA fosters reservations about the broader implications of using them for international climate policy negotiations.

Cooperation or retaliation?

BCA proposals have been floated not only as a measure to combat leakage but also as a means to secure greater cooperation: to avoid tariffs, other nations could adopt equivalent emissions pricing[73,74]. The terms-of-trade effect establishes the economic rationale of BCA as a sanctioning instrument. Numerical simulation studies that incorporate the strategic behaviour of individual countries suggest that import adjustments could coerce a broader international cooperation in emissions pricing under certain conditions[75–77]. When cast more broadly as uniform percentage tariffs on the imports of outsiders, a carbon club may even induce a large, stable coalition with high levels of abatement[78]. In this vein, a climate club that combines emissions pricing with trade sanctions could be a game changer. However, such sanctions are more likely than BCA to conflict with WTO obligations and induce trade disputes. Recent economic analyses show that the additional consideration of retaliation significantly reduces the appeal of import adjustments as a means to expand climate coalitions and may even risk a detrimental trade war[79,80].

From a legal perspective, import charges in WTO-compatible BCAs may not be sufficient to bring many pollution-intensive countries into a carbon-pricing coalition[51,78]. Moreover, the use of BCA as leverage for country-specific actions, as opposed to leakage prevention, could violate common but differentiated responsibilities principles. In international climate negotiations, BCAs could lead countries to reduce their voluntary commitments under the Paris Agreement, which would undermine the strategic value of BCA as a sanctioning instrument. China, as a prime example, responded to the EU's proposal for import adjustments by saying such a policy would seriously undermine international efforts to fight global warming; other large non-OECD countries, such as India, Indonesia and Thailand, share the view that BCA is a protectionist and discriminatory policy measure that they will oppose[81].

In the end, to what degree the strategic responses to BCAs affect the four criteria discussed above is still an open question.

Are there other anti-leakage instruments?

The potential of BCAs to trigger international trade wars and undermine cooperation in international climate policy raises the question whether alternative instruments to supplement unilateral emissions pricing might be less divisive under WTO rules. The short answer is yes, although they have their own drawbacks.

The first and most widely used option so far is output-based rebating (OBR), in which EITE firms receive free allowances or offsets in proportion to their production needs. This option, used in the EU, California, Canada and New Zealand, means that firms can still reduce their carbon payments by reducing their emissions, but they do not bear the full costs of the remaining embodied emissions, which relieves competitiveness pressures. However, a disadvantage of this approach—which effectively subsidizes output—is that carbon costs are not sufficiently passed on to consumers and users of EITE products. As a result, the incentives to conserve emissions are weakened and low-carbon substitutes are disadvantaged. Although OBR may be reasonably effective for individual countries, the costs of the output subsidies can exceed the benefit of avoided leakage for larger groups of emissions-pricing countries[53].

A novel approach is to complement OBR with consumption taxes to create a 'behind-the-border' approach that mimics full BCAs with uniform benchmarks[82]. The idea is to use OBR to address leakage and competitiveness concerns while adding a tax on the consumption of EITE inputs—a tax that applies equally to domestic and imported goods—to send corrected price signals to the consumers[83–85]. Whereas BCAs are controversial under current WTO rules, a similar outcome can be achieved through a domestic rebate-tax scheme that is undoubtedly WTO compatible. Compared with import adjustments alone, the behind-the-border approach has the advantage of effectively rebating to exports, as exports are exempt from the consumption tax. From a practical perspective, the scheme is a straightforward extension of existing regulation, such as the output-based allocation to industries at risk of carbon leakage in the EU ETS. There are also no extra administrative costs in determining the consumption taxes as long as benchmarks for the output-based allocation rates are already set.

A major challenge with approaches that rely on OBR or output-based allocation is what to do when the domestic benchmarks become very low, such that both the rebates and the corresponding consumption taxes lose importance, whereas the burden of higher-cost low-carbon production remains. Indeed, the EU and other countries are planning a course towards net-zero emissions, which means fewer allowances will be freely allocated. Meanwhile, rebating more to a sector than it is actually incurring in emissions costs is likely to violate the Agreement on Subsidies and Countervailing Measures. At this point, given the large differences in carbon prices, BCA becomes more attractive to ambitious unilateral actors. The only alternative is to find a subsidy less likely to be disputed, such as subsidies that target emissions abatement rather than production.

Another approach receiving increasing attention involves rebating carbon-pricing revenues based on the emissions-intensity performance. Such policies reward additional emissions-intensity reductions—either by making output-based rebates more generous for cleaner firms (intensity-based output rebating) or by rebating a share of emissions payments (intensity-based emissions rebating). Recent economic research suggests that intensity-based rebates could offer similar protection against leakage and competitiveness losses for EITE industries while lowering the carbon price needed to achieve a given level of emissions reductions[86]. The latter effect can improve political feasibility and reduce carbon price disparity while promoting a faster clean transition.

Although the different rebating schemes may seem like attractive alternatives to BCA to avoid trade tensions, they are not a panacea. Like BCA, they can address leakage only through the competitiveness channel, and they cannot incentivize abatement efforts of individual firms abroad (as firm-specific carbon adjustments would). At the same time, they might be preferred by domestic EITE industries with a high share of imported embodied carbon and a strong export orientation, especially if export rebates are not considered feasible. If the EU consultations on carbon border adjustment mechanisms are any indication, industry remains reluctant to give up free allocations, even with border adjustments.

None of the alternatives can address the fundamental free-rider problem in international climate policy; however, the risk that rebate-oriented approaches will hinder efforts to achieve multilateral climate cooperation appears low.

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