Emissions Markets and International Trade

Jennifer Winter[*]

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Summary

This chapter explores the evolution of emissions markets and the role of international trade in affecting domestic climate policy. Emissions embodied in trade creates risk of emissions leakage — whereby economic activity leaves a jurisdiction for others with less stringent policy — as a result of unilateral domestic climate policy. Despite significant progress in the number of jurisdictions with emissions pricing, there remains substantial variation in the price levels and share of priced emissions across jurisdictions, creating scope for leakage that is to date mitigated by generally low prices. Moving forward, with expected increases in emissions prices, leakage risk becomes more important, as 22% of emissions are traded but only 12% of global gross output. The countries with the most exposure to leakage are developed and have emissions pricing in place already, in addition to lower emissions-intensity of production. These three facts mean that policies to prevent leakage will become increasingly important in the absence of concerted global action and continued differences in price levels. The European Union's proposed carbon border adjustment mechanism is a new option to mitigate leakage. However, there are numerous elements of its design that are uncertain and are unlikely to be easily resolved, such as treatment of third countries, that may undermine its effectiveness.

[*] Associate Professor, Department of Economics and Scientific Director, Energy and Environmental Policy Research Division, School of Public Policy, University of Calgary.

Introduction

Despite the often-contentious politics of market-based emissions policies,[1] the past two decades have seen important changes to and expansions of emissions markets. In 2021, there were 65 emissions-pricing mechanisms across 47 countries and 58 separate jurisdictions (national, subnational and regional), with an additional four scheduled for future implementation, and 26 jurisdictions considering implementation.[2] Even with this progress, emissions prices remain low — below $20 USD per tonne of CO_2e — for the majority of countries. This is despite increasingly ambitious emissions-reduction targets[3] from signatories to the Paris Agreement, the international treaty to limit global warming below 2°C relative to pre-industrial levels.[4] Moreover, there is large variation in emissions price levels and the share of emissions priced across jurisdictions. This variation is potentially concerning from the perspective of domestic competitiveness, though currently mitigated by the generally low price levels.

In 2016, 22% of global emissions were traded internationally, embodied in goods and services produced in one country and sold to another.[5] In the same year, 12% of global gross output was traded.[6] Emissions matter for trade. With nearly a quarter of global emissions consumed in a jurisdiction other than the source, uncoordinated global climate policy means that climate policy has the potential to significantly affect and disrupt international trade. Moreover, domestic climate policy generally focuses on domestic emissions with little consideration of imported emissions, and trade policy largely ignores environmental problems.

This chapter explores the relationship between emissions, emissions markets and trade, commenting on the potential interactions between increasingly aggressive domestic emissions mitigation policy and international trade relationships. A widely recognized barrier

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[1] For example, the yellow vest protests in France, or Canadian provincial governments challenging the constitutionality of the federal carbon tax.

[2] World Bank, “Carbon Pricing Dashboard,” April 1, 2021, https://carbonpricingdashboard.worldbank.org/.

[3] Known as nationally determined contributions, or NDCs.

[4] UNFCCC, “The Paris Agreement,” accessed April 9, 2021, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

[5] KGM & Associated Pty Ltd, “The Eora Global Supply Chain Database,” n.d., https://worldmrio.com/.

[6] OECD Stat, “Trade in Value Added (TiVA) 2021 Ed: Principal Indicators,” November 2021, https://stats.oecd.org/Index.aspx?DataSetCode=TIVA_2021_C1.

to implementing emissions pricing or price increases in countries with a price in place is the issue of trade and competitiveness.[7] The political and economic concern is that unilateral action will increase costs for domestic firms, limiting their ability to compete in domestic and international markets. The fear is that economic activity will leave a jurisdiction implementing pricing, or increasing the price level, for another with less stringent environmental regulation, resulting in little or no net reduction in global emissions — emissions or carbon leakage[8] — and lowering economic activity in the country with emissions pricing. While there are policy options to mitigate leakage (discussed further below), a key obstacle is that Article 2 of the Paris Agreement states the "Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances."[9] This principle has its origin in the 1992 United Nations Framework Convention on Climate Change, which explicitly states "developed country Parties should take the lead in combating climate change and the adverse effects thereof."[10] Accordingly, developed nations are expected to engage in more stringent emissions-reduction policies, which will affect their terms of trade.

We find the majority of countries with emissions pricing are developed ones, and low prices (combined with policy to mitigate leakage) has limited the effect of unilateral action. However, developed countries with emissions pricing in place have high exposure to leakage, and the emissions intensity of production in developing nations is substantially higher than for developed nations. Two of the outcomes of COP26 — the 2021 United Nations climate change conference — are (1) an agreement for parties to review their 2030 emissions

[7] Carolyn Fischer and Alan K. Fox, "Comparing Policies to Combat Emissions Leakage: Border Carbon Adjustments versus Rebates," *Journal of Environmental Economics and Management* 64, no. 2 (September 1, 2012): 199–216, https://doi.org/10.1016/j.jeem.2012.01.005; High-Level Commission on Carbon Prices, "Report of the High-Level Commission on Carbon Prices," Report of the High-Level Commission on Carbon Prices (Washington, DC: World Bank, May 29, 2017), https://static1.squarespace.com/static/54ff9c5ce4b0a53decccfb4c/t/59b7f2409f8dce5316811916/1505227332748/CarbonPricing_FullReport.pdf; Christoph Böhringer et al., "Potential Impacts and Challenges of Border Carbon Adjustments," *Nature Climate Change*, January 3, 2022, 1–8, https://doi.org/10.1038/s41558-021-01250-z.

[8] There are numerous channels for leakage: energy markets, competitiveness, and induced innovation; see Carolyn Fischer, "Options for Avoiding Carbon Leakage," in *Towards a Workable and Effective Climate Regime* (Vox, 2015), 15. As trade and competitiveness is the focus of this chapter, we restrict analysis to the competitiveness channel.

[9] United Nations, "Paris Agreement," December 12, 2015, 3, https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

[10] United Nations, "UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE" (1992), 9.

reduction targets in 2022 and strengthen as necessary to align with Paris Agreement temperature goals, and (2) submit long-term strategies for net zero emissions by mid-century.[11] This means that as developed countries engage in increasingly stringent policy to address their Paris Agreement commitments, the relationship between trade policy and environmental policy will become increasingly important.

Historically, countries have addressed their leakage concerns by domestic measures to mitigate cost increases on domestic industries, such as allocating emissions permits for free rather than via auction. However, there is increasing interest in border carbon adjustments (BCAs) — taxing emissions embodied in imports — as an alternative. This includes the European Union's proposed carbon border adjustment mechanism, and investigation of BCAs by Canada, the United Kingdom, and the United States.[12] At risk, however, is that by moving to BCAs, developed countries push more of the burden of emissions reductions onto developing nations, an action inconsistent with Article 2 of the Paris Agreement.

The remainder of the chapter proceeds as follows. We begin with a brief overview of the types of emissions pricing instruments and mechanisms to address competitiveness effects of emissions pricing. We then cover the evolution of emissions pricing instruments across jurisdictions. Next, we discuss the relationship between international trade and emissions, and address the EU's proposal for a carbon border adjustment as a case study. Finally, we offer conclusions and a look ahead at the near-term future of emissions markets.

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[11] UK Government, "COP26: The Negotiations Explained" (UN Clumate Change Conference UK 2021, 2021), https://ukcop26.org/wp-content/uploads/2021/11/COP26-Negotiations-Explained.pdf; United Nations, UN Climate Change Conference UK 2021, and UK Government, "COP26: The Glasgow Climate Pact" (UN Clumate Change Conference UK 2021, 2021), https://ukcop26.org/wp-content/uploads/2021/11/COP26-Presidency-Outcomes-The-Climate-Pact.pdf.

[12] Susanne Droege and Carolyn Fischer, "Pricing Carbon at the Border: Key Questions for the EU," *Ifo DICE Report* 18, no. 1 (2020): 30–34; Department of Finance, "Exploring Border Carbon Adjustments for Canada," Government of Canada, August 5, 2021, https://www.canada.ca/en/department-finance/programs/consultations/2021/border-carbon-adjustments/exploring-border-carbon-adjustments-canada.html; European Commission, "Carbon Border Adjustment Mechanism: Questions and Answers," Text, European Commission - European Commission, July 14, 2021, https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661; UK Parliament, "Committees - Carbon Border Adjustment Mechanisms," accessed January 12, 2022, https://committees.parliament.uk/work/1535/carbon-border-adjustment-mechanisms/.

Background and context: Types of emissions pricing instruments

This section provides a brief review of the common types of emissions pricing instruments and mechanisms to address competitiveness when countries or subnational jurisdictions consider unilateral action, providing context for the remainder of this chapter.

Types of emissions-pricing instruments

There are three general types of emissions pricing instruments in place globally. First, explicit emissions taxes or regulatory charges, usually implemented on fossil fuel combustion and applied at the point of sale. These systems set a price on greenhouse gas emissions and rely on behavioural responses to reduce emissions. An example is the BC carbon tax. Second, cap-and-trade or emissions trading systems, typically applied to large industrial emitters (e.g. refineries, cement, electricity, etc.), which may include combustion emissions and GHGs from industrial processing and product use. These systems limit the annual quantity of emissions, and emissions-permit trading determines the price. Businesses pass the cost of emissions through to consumers and other businesses implicitly, rather than explicitly as with emissions taxes.[13] Prominent examples include the EU ETS and the Quebec-California cap and trade system.

Third, performance standards. These systems set firm-, facility- or product-level emissions performance standards, typically tonnes of CO_2-equivalent (CO_2e) per unit of output, where firms must pay a tax or purchase permits (or both) for emissions in excess of their performance standard. An extension of this instrument includes an explicit (maximum) price and tradeable permits, frequently described as a tradeable performance standard. Examples include Canada's federal output-based pricing system and China's national power-sector ETS. The third type of system is frequently classified as an emissions trading system, most notably by the World Bank in its annual carbon pricing reports, but it is a distinct way of pricing emissions. The key difference is the lack of a firm cap on emissions from covered facilities, and the fact that compliance depends on the ratio of emissions to output rather than an absolute measure.

[13] In some instances (e.g. Quebec), fuel distributors are required to purchase emissions permits for the quantity of fuel they sell directly to consumers, and so the cost pass-through can be direct.

Adding complexity to these systems is that layered within the three approaches are a myriad of design elements. Design elements include, but are not limited to, the emissions price in the case of taxes and tradeable permit systems, the cap and any minimum permit price for cap and trade systems, the types of greenhouse gas emissions priced, economic sectors or activities subject to the system, exemptions, domestic cost-containment measures, and treatment of extra-jurisdictional production. Competitiveness of domestic industry is a key consideration in design and implementation, which we describe in the next section. Moreover, many jurisdictions rely on a combination of emissions pricing instruments, rather than a single system. For example, of the 30 countries participating in the EU ETS[14], 17 also have domestic systems (predominantly carbon taxes).[15] In some cases (e.g. France and Germany), the domestic system covers sectors exempt from the ETS, whereas for other countries (e.g. Sweden) the emissions price is complimentary and overlaps with the EU ETS. Similarly, Canada's federal system and most provinces implemented a charge on fossil fuel combustion and a separate system for large emitters to address competitiveness concerns.

Mechanisms to address competitiveness and limit leakage

There are three main mechanisms jurisdictions have at their disposal to address the issue of domestic and international competitiveness and limit leakage, though again these mechanisms come with a variety of policy design options. The first is exemptions, either in whole or in part, from the emissions price. The second is within-jurisdiction actions to reduce the costs of emissions pricing, such as free allocation of emissions permits or using tax revenues to provide rebates. The third is border carbon adjustments (BCAs). The effect and efficacy of these three mechanisms differ (Table 1).

Recall that emissions pricing, regardless of its form, raises the cost of emissions-intensive inputs to production such as fossil-fuel-based energy. This in turn raises the cost of production. With unilateral action, domestic firms become higher cost producers relative to their international competitors, which can cause both domestic (as domestic consumers buy more international imports) and international (as international consumers import less from the implementing jurisdiction) contraction and emissions leakage.

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[14] All EU countries plus Iceland, Liechtenstein and Norway.

[15] World Bank, "Carbon Pricing Dashboard."

Exemptions create a differential price on energy use or emissions in some economic sectors. While administratively simple, exemptions have three major drawbacks.[16] First, the exemption lowers the emissions-reduction incentive in the affected industries, undermining the purpose of the emissions pricing mechanism. Second, and relatedly, the lesser incentive means some emission-reduction opportunities will be ignored, which results in fewer emissions reductions or requires more action by industries facing the full price. Third, a differential emissions price across industries affects within-country competitiveness, and can lead to misallocation of resources and lower productivity.[17] Examples of this in practice include Canada exempting fuel use in agriculture from its federal carbon tax, and Sweden exempting industry from its carbon tax.[18]

While the specific nuances of policy design are outside of the scope of this chapter, within-jurisdiction adjustments generally provide a subsidy to affected firms.[19,20] This lowers the average cost of emissions, and hence the average cost of production, while (when designed appropriately) maintaining the per-tonne marginal price signal. The subsidy signals to firms that emissions reductions should occur via intensity improvements rather than output reductions.[21] These adjustments, by mitigating the full cost of emissions pricing, protect firms' competitiveness domestically and internationally. Design also generally includes a transition mechanism to lower the subsidy level over time, under the assumption that (1) firms will adjust their production processes to reduce emissions; and (2) other jurisdictions

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[16] Fischer, "Options for Avoiding Carbon Leakage"; Sarah Dobson and Jennifer Winter, "Assessing Policy Support for Emissions Intensive and Trade Exposed Industries," *The School of Public Policy Publications* 11 (October 25, 2018), https://doi.org/10.11575/sppp.v11i0.43673.

[17] Trevor Tombe and Jennifer Winter, "Environmental Policy and Misallocation: The Productivity Effect of Intensity Standards," *Journal of Environmental Economics and Management* 72 (July 1, 2015): 137–63, https://doi.org/10.1016/j.jeem.2015.06.002.

[18] Canada Revenue Agency, "Fuel Charge Relief," December 27, 2019, https://www.canada.ca/en/revenue-agency/services/tax/excise-taxes-duties-levies/fuel-charge/relief.html; Ministry of Finance, "Carbon Taxation in Sweden" (Government Offices of Sweden, January 2021), https://www.government.se/48e407/contentassets/419eb2cafa93423c891c09cb9914801b/210111-carbon-tax-sweden---general-info.pdf.

[19] For an overview of the principles of policy design, see Sarah Dobson et al., "The Ground Rules for Effective OBAs: Principles for Addressing Carbon-Pricing Competitiveness Concerns through the Use of Output-Based Allocations," *The School of Public Policy Publications* 10 (June 29, 2017), https://doi.org/10.11575/sppp.v10i0.42633.

[20] For an overview of policies in practice, see Dobson and Winter, "Assessing Policy Support for Emissions Intensive and Trade Exposed Industries."

[21] Fischer, "Options for Avoiding Carbon Leakage."

will implement emissions pricing, lessening the need for protective measures. Examples of this type of mechanism in practice include Canada's federal output-based pricing system, the EU ETS free allocation of permits, and China's national electricity-sector ETS.

In contrast, border carbon adjustments price the embodied emissions on imports at the border. That is, it applies the same carbon tax or ETS price to foreign firms. This preserves domestic firms' competitiveness in *domestic* markets relative to imports from other jurisdictions. Preserving international competitiveness requires a matching adjustment or rebate that removes the tax at the export point. Examples of this type of mechanism in practice include the United Kingdom's former top-up to the EU ETS emissions price (called the carbon price floor) and California's inclusion of electricity imports in its cap and trade system.[22]

An important distinction between the latter two mechanisms, and one that matters for trade, is treatment of imports. A BCA requires assigning an emissions-intensity benchmark to imports, potentially specific to industries, products and countries. This increases the information burden on the implementing country, as well as the administrative complexity. Including adjustments for emissions pricing in other jurisdictions in BCA design exacerbates the knowledge requirement and administrative complexity. In contrast, output-based rebates or free permit allocations only requires knowledge of domestic emissions at covered facilities.

Table 1: Comparison of competitiveness mechanisms relative to full pricing

	Exemptions	**Output-based rebates or free permit allocations**	**Border carbon adjustments**
Emissions reduction incentive	Limited.	Marginal incentive remains. Subsidy increases output and emissions. Mutes signal to end consumers.	Full incentive.

[22] David Hirst and Matthew Keep, "Carbon Price Floor (CPF) and the Price Support Mechanism," Briefing Paper (House of Commons Library, January 8, 2018), https://commonslibrary.parliament.uk/research-briefings/sn05927/; California Air Resources Board, "Final Regulation Order California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms" (California, April 1, 2019), https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2018/capandtrade18/ct18fro.pdf?_ga=2.130525967.1440075814.1642273118-1260108448.1642273118.

Marginal cost of emissions	Lower	No change.	No change.
Average cost of emissions	Lower	Lower.	No change.
Emissions intensity	No change.	Decreases.	Decreases.
Reduces leakage?	Yes, by lowering or removing cost effects for covered firms.	Yes, lowers average cost of emissions for domestic firms.	Fee on imports protects domestic firms from international competitors. Rebate on exports supports international competition by domestic firms.
Trade issues	Implicit subsidy, but unlikely to be substantive.	Could be challenged as subsidies or preferential treatment.	Risk of other countries' imposing retaliatory tariffs.
Costs	Foregone revenue.	Subsidizes output. Foregone revenue from full emissions pricing.	Raises revenue on imports. Foregone revenue from emissions pricing rebate on exports.
Administrative complexity	Low. Likely able to implement through tax system.	Medium. Requires firm- or facility-specific data.	High.

There are differential trade implications for the three mechanisms. While exemptions are an implicit subsidy, they are a domestic issue and not explicitly trade-related, limiting any potential international disputes. Adjustments via output-based rebates or free allocations are also subsidies, and therefore could be considered preferential treatment and subject to challenge under the World Trade Organization (WTO). However, a mitigating factor is that free allocations are generally implemented via domestic regulation — performance standards with tradeable permits or cap and trade systems — with a net cost on emissions. BCAs in effect shift emissions pricing from production-based to consumption-based, moving from taxing emissions at the point of production to taxing the embodied emissions at the point of consumption. There are two main trade issues embodied in this policy choice.[23] First, WTO compliance requires demonstrating the BCA is "essential and effective for reducing leakage" and it "conforms to the principle of common but differentiated responsibilities"

[23] For a detailed review of the issues involved in BCA design, see Aaron Cosbey et al., "Developing Guidance for Implementing Border Carbon Adjustments: Lessons, Cautions, and Research Needs from the Literature," *Review of Environmental Economics and Policy* 13, no. 1 (January 1, 2019): 3–22, https://doi.org/10.1093/reep/rey020.

embodied in the Paris Agreement and other international environmental law.[24] Several scholars suggest BCAs are WTO compliant,[25] while others argue they are vulnerable to a discriminatory challenge under WTO rules.[26] Second, by moving emissions pricing to a consumption basis, the emissions intensity of countries' production matters. Developing countries, with higher energy and emissions intensity, are most likely to be affected.[27] However, leakage is not a universal concern across economic sectors; the majority of benefits come from supporting industries designated as emissions-intensive and trade-exposed (EITE) and so restricting BCA coverage to these sectors could mitigate burden-shifting to developing countries.[28]

Importantly, a trade issue embodied in the politics of emissions pricing is the moral suasion or normative power of unilateral action and choice of policy mechanism. As a collective action problem, addressing emissions means there is always an incentive for countries to free ride on others' emissions reductions, receiving the benefit of lower global emissions without incurring economic costs. This issue is part of the rationale for limited unilateral action, and why mechanisms to address competitiveness have an important role in policy design. As domestic policies, exemptions and free allocations have little ability to influence other jurisdictions' policy choices. In contrast, BCAs, as an explicit trade policy, could prompt other countries to increase the stringency of their emissions pricing to reduce the import tariff, particularly if the BCA adjusts for foreign emissions prices.

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[24] Fischer, "Options for Avoiding Carbon Leakage," 305.

[25] Henrik Horn and Petros C. Mavroidis, "To B(TA) or Not to B(TA)? On the Legality and Desirability of Border Tax Adjustments from a Trade Perspective," *The World Economy* 34, no. 11 (2011): 1911–37, https://doi.org/10.1111/j.1467-9701.2011.01423.x; Cosbey et al., "Developing Guidance for Implementing Border Carbon Adjustments."

[26] Madison Condon and Ada Ignaciuk, "Border Carbon Adjustment and International Trade: A Literature Review," OECD Trade and Environment Working Papers (Paris: OECD, October 31, 2013), https://doi.org/10.1787/5k3xn25b386c-en; Joost Pauwelyn, "Trade Related Aspects of a Carbon Border Adjustment Mechanism. A Legal Assessment," Briefing (European Parliament Committee on International Trade, April 2020), https://www.europarl.europa.eu/thinktank/en/document/EXPO_BRI(2020)603502.

[27] Hannah Ritchie, "How Much Energy Do Countries Consume When We Take Offshoring into Account?," Our World in Data, December 7, 2021, https://ourworldindata.org/energy-offshoring; Our World in Data, "CO_2 Emissions Embedded in Trade," Our World in Data, accessed January 7, 2022, https://ourworldindata.org/grapher/share-co2-embedded-in-trade.

[28] Fischer, "Options for Avoiding Carbon Leakage"; Cosbey et al., "Developing Guidance for Implementing Border Carbon Adjustments."

We now turn to emissions-pricing instruments in practice and their evolution, before returning to the current issues of trade and emissions markets.

A brief history of emissions-pricing instruments

This section provides an overview of the evolution of emissions markets between 1990 and 2021. There are three key issues when considering the interaction between emissions, emissions pricing, and trade. First is the simple presence of pricing: the number of jurisdictions implementing an emissions-pricing instrument. Second is coverage: the share of domestic and global emissions subject to a pricing instrument. Third is stringency: the amount of the emissions-reduction incentive in jurisdictions with pricing. We cover each in turn.

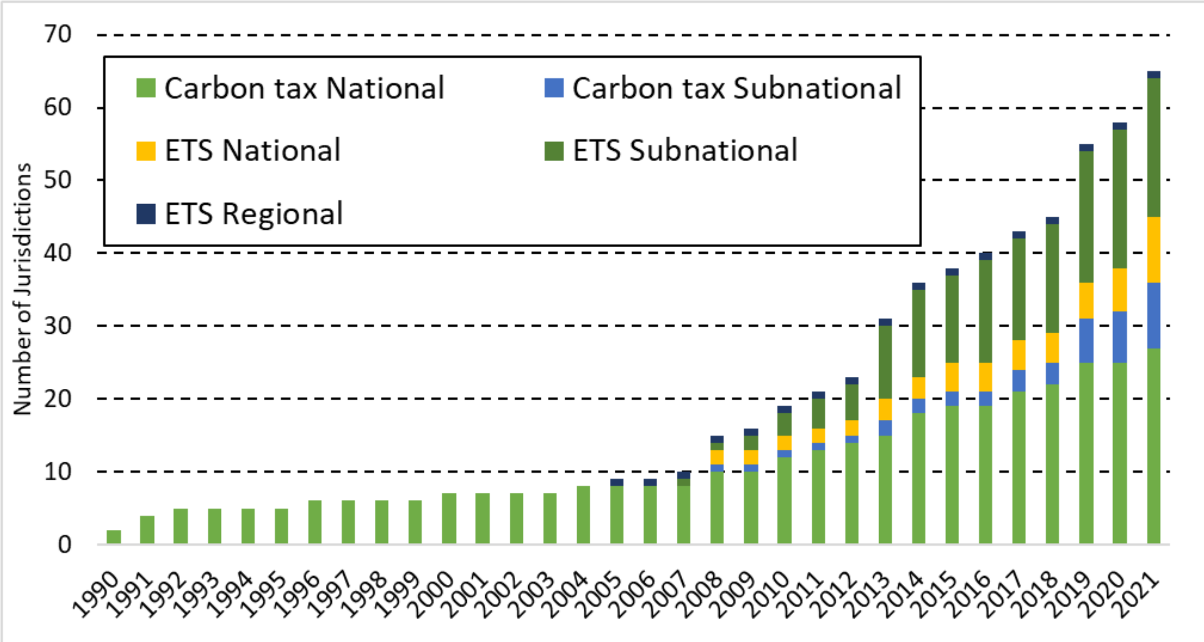
Explicit emissions pricing started in 1990, when Finland and Poland each implemented carbon taxes (Figure 1). The 1990s and early 2000s saw a slow introduction of emissions pricing via carbon taxes in Europe,[29] with the number of jurisdictions implementing pricing increasing steadily following the introduction of the European Union emissions trading system (ETS) in 2005. Other major steps forward include Japan's carbon tax (2012), several city-level ETS pilots in China,[30] the California-Quebec cap and trade system, and Canada's federal emissions pricing benchmark (which also prompted numerous subnational programs). As of 2021, 65 jurisdictions (including 45 national and 34 subnational systems) had emissions-pricing instruments in operation, covering an estimated 21.5% of global emissions.[31] The majority of countries with emissions pricing are European, or developed (high-income) countries; Table 2 outlines emissions pricing instruments for the G20.

Figure 1: Number of jurisdictions implementing emissions pricing, 1990-2021

[29] Norway (1991), Sweden (1991), Denmark (1992), Slovenia (1996), Estonia (2000) and Latvia (2004).

[30] Beijing (2013), Guangdong (2013), Shanghai (2013), Shenzhen (2013), Tianjin (2013), Chongqing (2014), Hubei (2014), and Fujian (2016).

[31] World Bank, "State and Trends of Carbon Pricing 2021," Serial (Washington, DC: World Bank, May 25, 2021), https://doi.org/10.1596/978-1-4648-1728-1; World Bank, "Carbon Pricing Dashboard."



Source: World Bank, "Carbon Pricing Dashboard."

Note: There is potential overlap between national and subnational or national and regional initiatives (e.g. the EU ETS and national programs); both are counted. Implemented means programs formally adopted through legislation with an official start date. ETS includes cap and trade systems as well as tradeable performance standards, and excludes baseline and offset programs. Subnational includes subnational states, joint initiatives between subnational states (e.g. RGGI), and city-level programs.

Table 2: G20 Emissions Pricing Mechanisms as of 2021

Country	Type	Status	Description
Argentina	Tax	Implemented (2018)	Applies on most liquid fuels. Some exemptions for specific sectors.
Australia	None		
Brazil	ETS	Under consideration	
Canada	Hybrid	Implemented (2019)	Regulatory charge on fossil fuels and performance standard with output-based rebates for facilities designated as emissions-intensive and trade-exposed. Provinces and territories can implement own system that meets federal minimum standard.
China	ETS	Implemented (2021)	Applies to CO_2 emissions from electricity generation. Performance standard and output-based rebating.
France	Tax	Implemented (2014)	Applies to CO_2 emissions from industry, building and transport sectors. Facilities covered by ETS are exempt. Some exemptions for specific sectors.

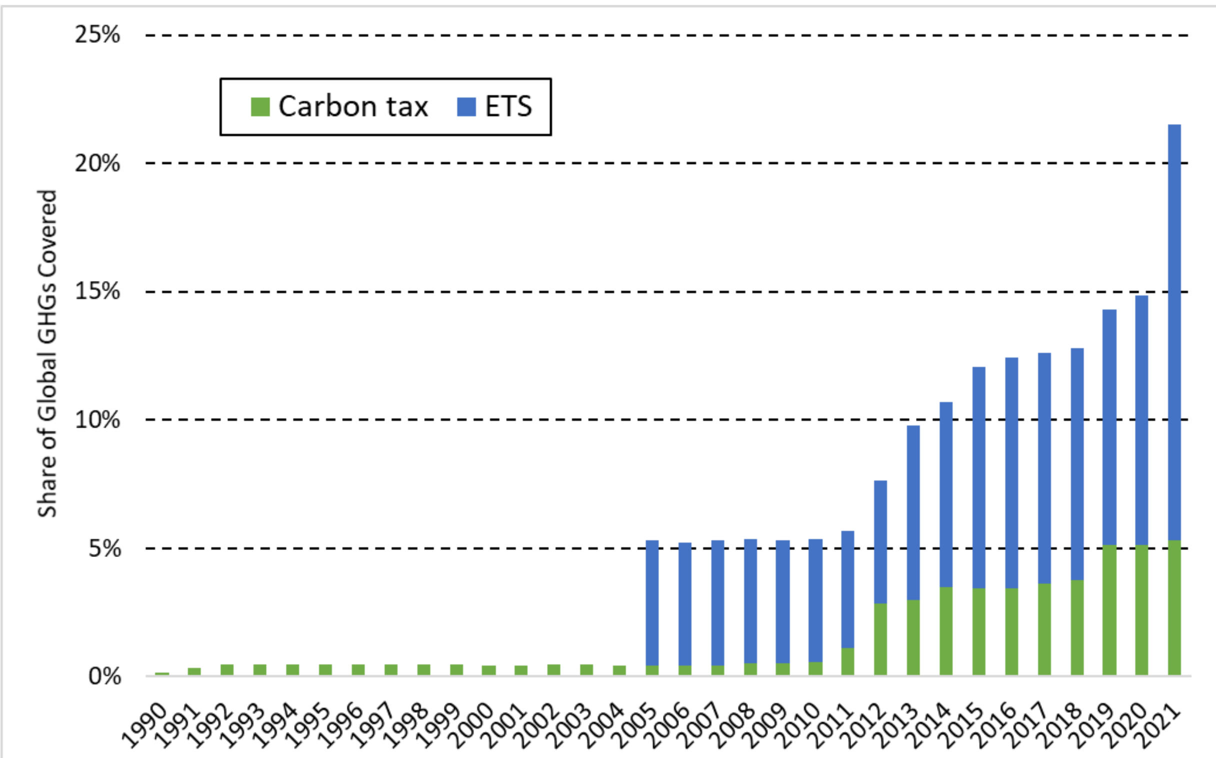
Germany	ETS	Implemented (2021)	Cap and trade system, with compensation for EITE sectors. Applies to GHG emissions from buildings and road transport.
India	None		
Indonesia	Tax	Scheduled (2022)	Tax on coal-fired electricity generation. ETS under consideration.
Italy	None		
Japan	Tax	Implemented (2012)	Applies to CO_2 emissions from all sectors, with some exemptions by sector. ETS under consideration.
R. of Korea	ETS	Implemented (2015)	Cap and trade system on GHG emissions from industry, power, buildings, domestic aviation, public sector, and waste; permits distributed primarily by free allocation.
Mexico	Tax	Implemented (2014)	Applies to CO_2 emissions from fossil fuels, relative to emissions content of natural gas. ETS being piloted, covering power, oil and gas, and industrial sectors.
Russia	None		
Saudi Arabia	None		
South Africa	Tax	Implemented (2019)	Applies to GHG emissions from industry, power, buildings and transport sectors. Some exemptions for specific sectors. Residential transport exempt.
Turkey	ETS	Under consideration	
United Kingdom	Hybrid	Implemented (2013)	Carbon price floor on fossil-fuel-based electricity generation. Cap and trade system introduced in 2021 following Brexit, covering GHG emissions from electricity generation, energy-intensive industries and aviation. Free allowances distributed to EITE sectors.
United States	None	Two subnational ETS': (1) California cap and trade (2012), covering GHG emissions from industry, power, transport and buildings sectors. (2) Regional Greenhouse Gas Initiative (2009), covering CO_2 emissions from electricity generation in 10 states.	
European Union	ETS	Implemented (2005)	Applies to CO_2 emissions from industry, power and aviation, N_2O from specific chemical sectors, and PFC from aluminum production. Free allowances distributed to EITE sectors.

Sources: World Bank, "Carbon Pricing Dashboard," International Carbon Action Partnership, "Brazil," November 17, 2021, https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems[]=79.

Note: EITE is emissions-intensive and trade-exposed.

While the number of jurisdictions implementing carbon taxes is substantial — 36 in 2021 — the share of global emissions subject to a price, called *coverage*, is low relative to emissions trading systems[32] (Figure 2). The reason for this is twofold. First, for many of the jurisdictions with a carbon tax, though the taxes generally price combustion emissions, these countries are small contributors to overall global emissions. Second, many of the jurisdictions implement two systems: a carbon tax plus an ETS or a tradeable performance standard for large industrial emitters. These industrial emitters are a larger proportion of domestic emissions, and hence account for a large share of global and domestic coverage.

Figure 2: Share of global GHG emissions covered by emissions pricing, by type, 1990-2021



Source: World Bank, "Carbon Pricing Dashboard."

Note: Only introduction or removal is included in the data. ETS includes cap and trade as well as tradeable performance standards, and exclude baseline and offset programs. In the case of overlap between different pricing schemes, coverage is attributed to the pricing initiative introduced first.

[32] These include tradeable performance standards such as Canada's federal large emitter system, the output-based pricing system.

The large increase in coverage between 2020 and 2021 is due to China implementing its national ETS for the power sector, estimated to cover between 30 and 40% of China's emissions,[33] and 7.4% of global emissions in 2021.[34] Despite covering just the power sector, China's ETS is the largest emissions market in the world, with double the coverage of the EU ETS when measured as a share of global emissions. In terms of domestic emissions, the relative coverage is the same (39% for the EU ETS versus 30-40% for China). The planned expansion of China's ETS to cover petrochemicals, chemicals, building materials, steel production, nonferrous metals, paper manufacturing, and domestic aviation, and any accompanying policy design tweaks will likely have a significant effect moving forward.[35]

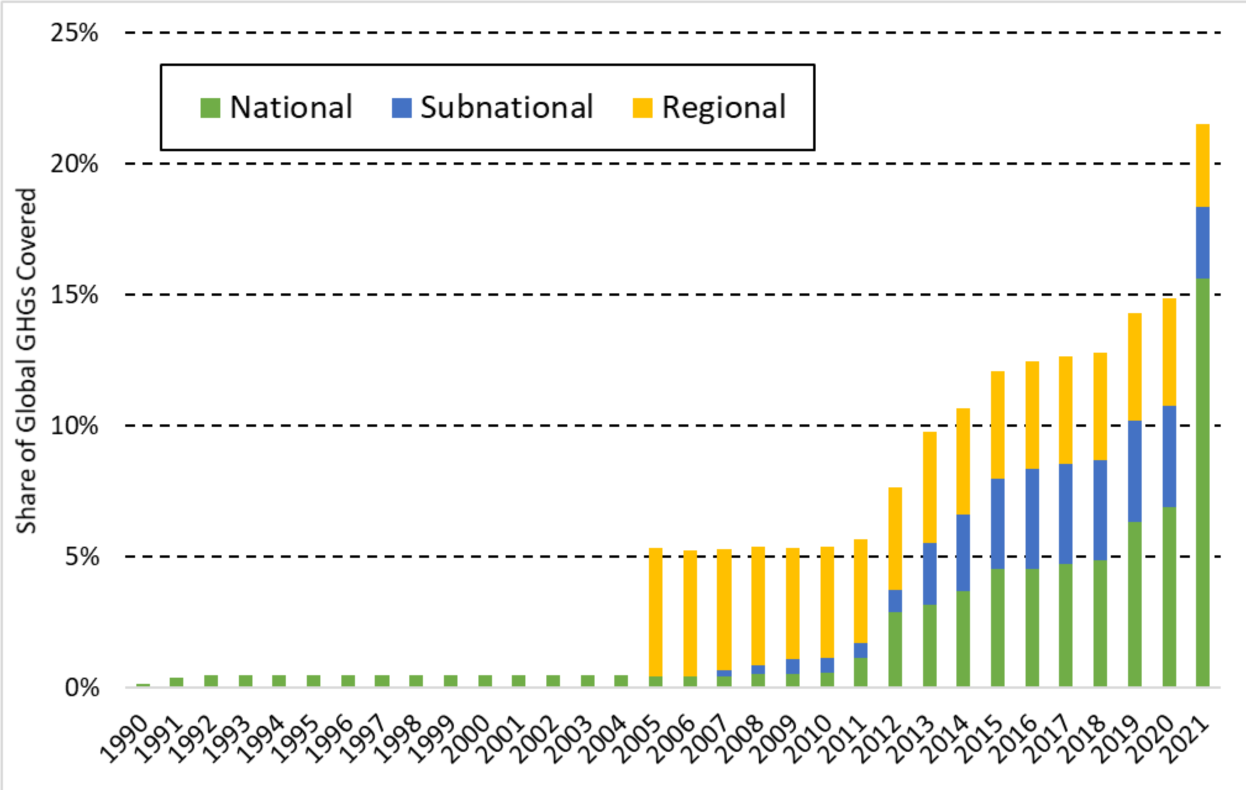
Also of note is the rise in subnational systems and their importance in coverage, compared to regions (the EU ETS) and national systems (Figure 3), which has implications for future policy design and trade. With increased interest in border carbon adjustments as an alternative to domestic competitiveness policy, accounting for subnational emissions pricing will make design of a BCA more complex.

Figure 3: Share of global GHG emissions covered by emissions pricing, by implementing jurisdiction, 1990-2021

[33] World Bank, "State and Trends of Carbon Pricing 2021"; Lawrence H. Goulder et al., "China's Unconventional Nationwide CO2 Emissions Trading System: Cost-Effectiveness and Distributional Impacts," *Journal of Environmental Economics and Management* 111 (January 1, 2022): 102561, https://doi.org/10.1016/j.jeem.2021.102561.

[34] World Bank, "Carbon Pricing Dashboard."

[35] IEA, "China's Emissions Trading Scheme" (Paris: International Energy Agency, June 2020), https://www.iea.org/reports/chinas-emissions-trading-scheme.



Source: World Bank, “Carbon Pricing Dashboard.”

Note: “Regional” is the EU ETS; regional but subnational initiatives such as the California-Quebec cap and trade system or the US Regional Greenhouse Gas Initiative (RGGI) are classified as subnational. Only introduction or removal is included in the data. ETS includes cap and trade as well as tradeable performance standards, and exclude baseline and offset programs. In the case of overlap between different pricing schemes, coverage is attributed to the pricing initiative introduced first.

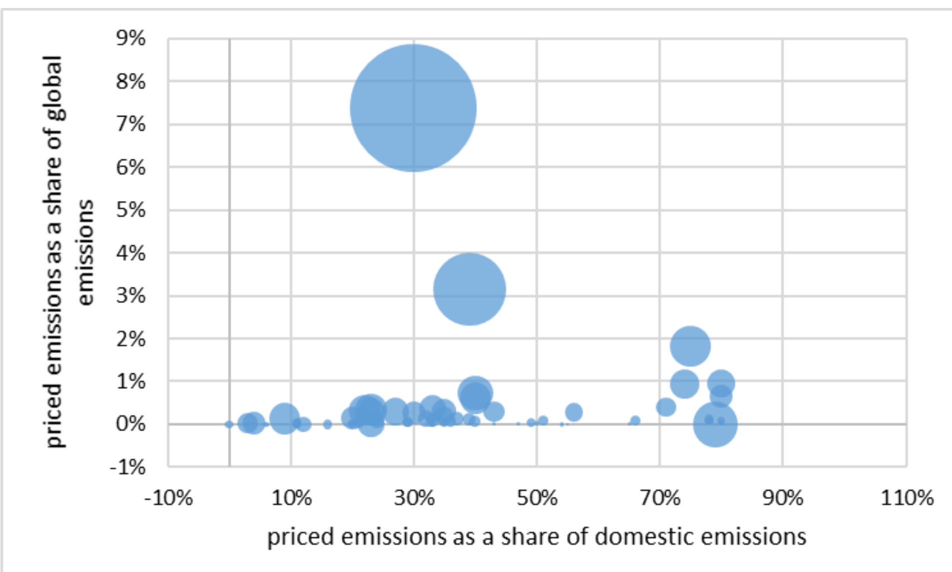
Figure 4 presents the relationship between coverage (share of emissions priced) and stringency (the price level). Panel A shows jurisdictional coverage compared to global coverage, and Panel B shows jurisdictional coverage compared to price levels; the size of the bubbles indicate total jurisdictional emissions. Panel A clearly shows the majority of pricing instruments have very little global coverage and relatively low domestic coverage — the majority of systems have less than 50% of emissions priced. This is despite the fact that the majority of global emissions are from fossil fuel combustion, and therefore simple to price.[36] In some instances, this is due to design choice. For example, Argentina’s tax covers liquid fuels and China’s covers only the power sector, leading to limited domestic coverage.

[36] Hannah Ritchie, “Sector by Sector: Where Do Global Greenhouse Gas Emissions Come From?,” Our World in Data, September 18, 2020, https://ourworldindata.org/ghg-emissions-by-sector.

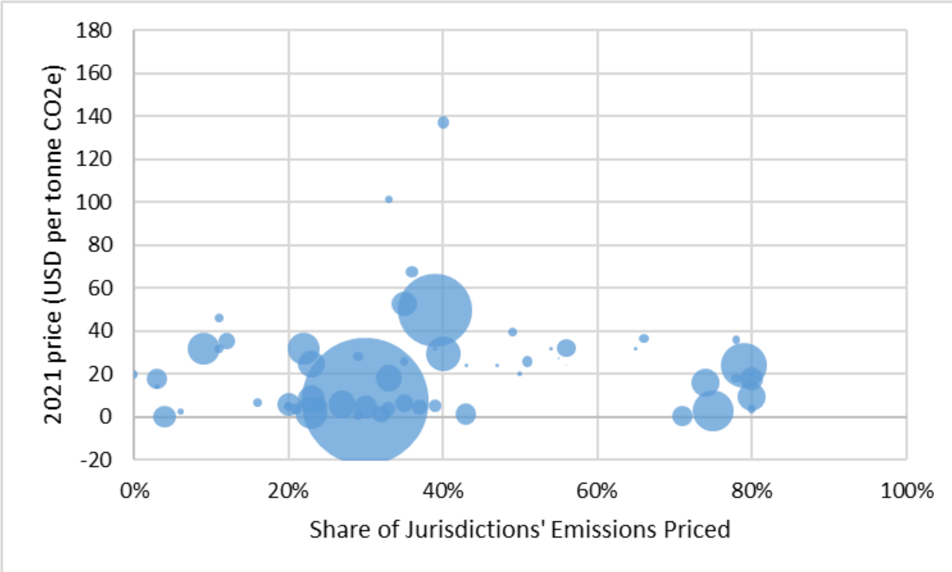
Similarly, the EU ETS excludes emissions from transportation and buildings. In other instances, the presence of multiple systems makes the coverage calculation complex. Some EU member countries have domestic instruments to top-up coverage of sectors unpriced by the ETS (e.g. Denmark, Germany), and most jurisdictions in Canada have two systems: a tax on consumers and small emitters, and a system for large industrial emitters. The presence of multiple systems understate domestic emissions coverage, which is reflected in the figure. A more accurate calculation of coverage is beyond the scope of this chapter, and the fundamental observation from the figure stands: those jurisdictions with emissions pricing generally have relatively low coverage and are relatively small contributors to global emissions. Both these factors undermine global efforts to reduce emissions, though they do mitigate leakage concerns.

Figure 4: Relationship between coverage and stringency

Panel A: Share of global emissions priced and share of domestic emissions priced



Panel B: Emissions prices and share of emissions priced



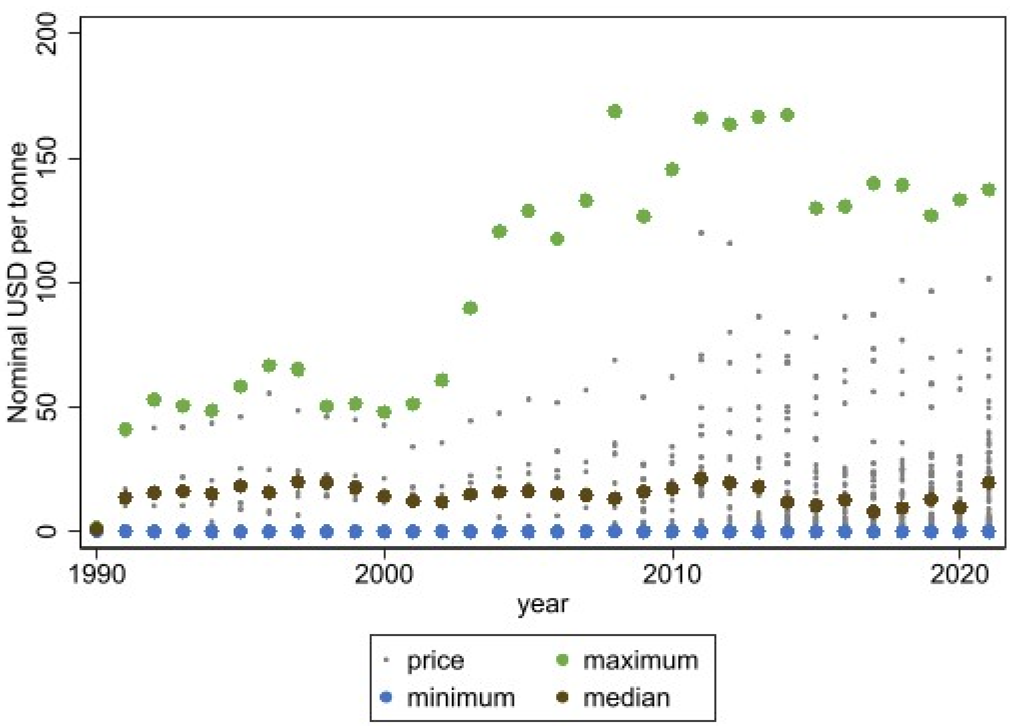
Source: World Bank, “Carbon Pricing Dashboard.” OECD, “Carbon Pricing in Times of COVID-19: What Has Changed in G20 Economies?” (Paris: OECD, October 27, 2021), https://www.oecd.org/tax/tax-policy/carbon-pricing-in-times-of-covid-19-what-has-changed-in-g20-economies.htm; International Carbon Action Partnership, “Allowance Price Explorer,” International Carbon Action Partnership, accessed January 5, 2022, https://icapcarbonaction.com/en/ets-prices.

Note: Price is 2021 values. Size of the bubble represents 2015 emissions. For jurisdictions with prices for different fuels (Denmark, Finland, Iceland, Luxembourg, Mexico, Norway), price is calculated using the simple average of the maximum and minimum.

Both Panel A and Panel B show large variation in prices and coverage across jurisdictions. These differences raise issues of competitiveness, though this is likely mitigated by relatively low prices. These differences are likely to become more important with increasingly aggressive action to reduce emissions, particularly for jurisdictions considering integrating trade and environmental policy via border carbon adjustments. Finally, Panel B shows there is almost no correlation (0.01) between the share of emissions priced and the emissions price. There is a slight negative correlation (-0.02) between total emissions and the share priced, and a slightly stronger relationship (-0.07) between total emissions and the price. The latter two correlations are consistent with leakage concerns: jurisdictions with higher emissions are more likely to have lower coverage and lower prices.

Turning to the stringency of emissions pricing, Figure 5 plots the distribution of prices over time, including minimum, maximum and median annual prices. Prices are not directly comparable across jurisdictions due to differences in coverage (economic sector and greenhouse gases, etc.), exemptions, and cost containment or revenue use measures such as free allocation of permits. Nevertheless, the prices present in the figure are an important measure of the stringency of emissions pricing in different markets. Importantly, though the number of jurisdictions implementing pricing has increased substantially over time, the median price has remained around $15 USD per tonne of CO_2e (nominal) between 1991 and 2021. This means that in any given year, 50% of jurisdictions with emissions pricing in place had a price below $15 per tonne.

Figure 5: Emissions pricing in nominal USD per tonne, 1990 to 2021



Source: World Bank, "Carbon Pricing Dashboard." OECD, "Carbon Pricing in Times of COVID-19"; International Carbon Action Partnership, "Allowance Price Explorer."

Note: Includes only jurisdictions with active emissions pricing. Prices for all countries except for China and the UK ETS are as-of April 1, 2021; prices for China and UK ETS are end-of-2021. Norway has a minimum and a maximum price, which also differs by fuel; only minimum and maximum are included. Sweden had a minimum and maximum price from 1992 to 2016, which differed by economic sector and some fuels; only the minimum and maximum are included for that period. In 2011, Finland implemented differential pricing for liquid transport fuels and other fossil fuels. In 2014, Ireland introduced a differential rate for solid fuels, and it rose to match other fuels in subsequent years; both are included. In 2014, Mexico introduced a carbon tax for each fossil fuel, on the additional CO_2 emissions relative to natural gas; only minimum and maximum are included. In 2017, Denmark differentiated between solid fossil fuels and fossil gases. In 2018, Argentina introduced a carbon tax on most liquid fuels, and in 2019 added a differential rate on fuel oil, mineral coal and petroleum coke; all are included. Argentina paused its tax in 2020 in response to the pandemic, and reinstated it for liquid fuels in 2021. In 2020, Iceland introduced a differential tax rate on fossil gases; both are included. In 2021, Luxembourg introduced its carbon tax, which has differential prices for gasoline, diesel and "other" fossil fuels; all are included.

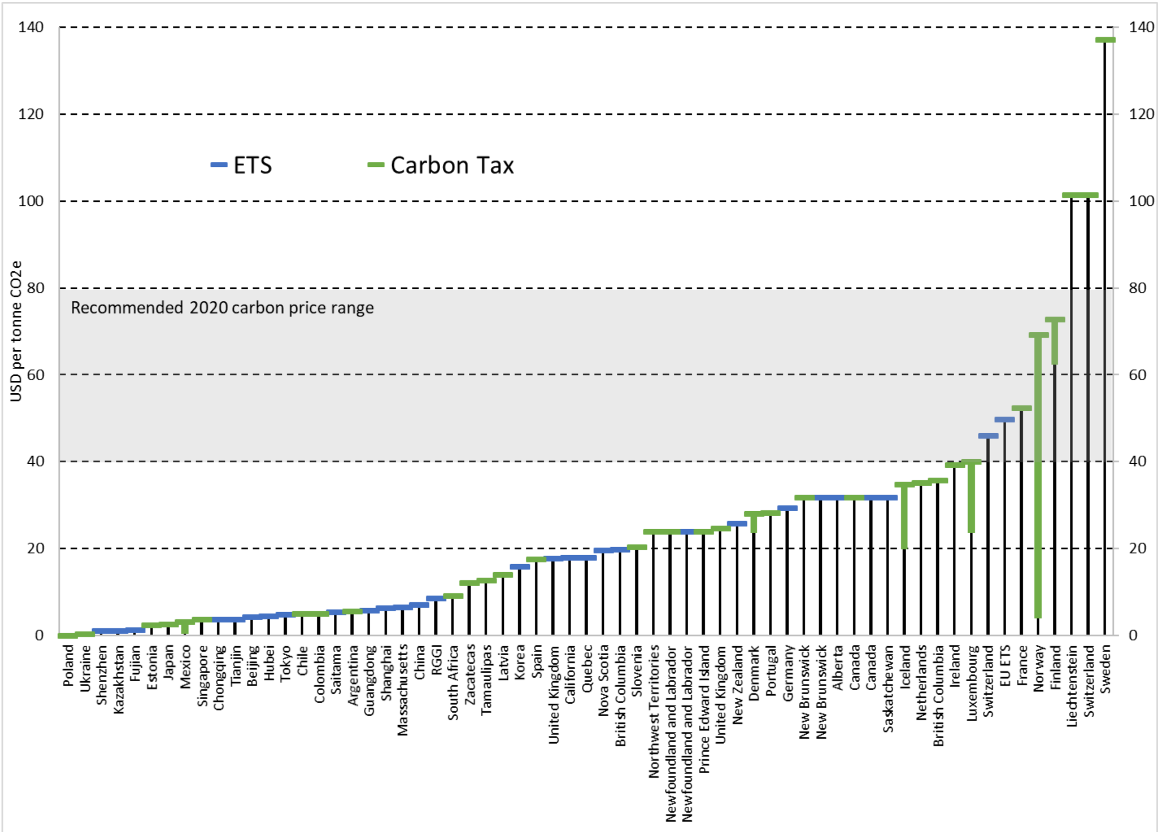
Historical and current prices are substantially below what is necessary to meet Paris Agreement targets, prices of $40-80 USD by 2020 and $50-100 by 2030.[37] In 2021, only seven prices were in the 2020 price range[38], and three were above[39], accounting for 3.75% of global emissions (Figure 5). Only six jurisdictions — France, Finland, Liechtenstein, Norway, Switzerland and Sweden — have prices in the recommended 2030 range, though the EU ETS price is just below $50. Notably, 12 EU member states with emissions pricing supplementary to the EU ETS have domestic prices below the ETS price, ranging from $0.08 (Poland) to $40 (Luxembourg).

[37] High-Level Commission on Carbon Prices, "Report of the High-Level Commission on Carbon Prices."

[38] EU ETS ($49.78), Finland carbon tax (liquid transport fuels: $72.83; other fossil fuels: $62.25), France carbon tax ($52.39), Luxembourg carbon tax (diesel: $40.12), Norway carbon tax (upper bound: $69.33), and Switzerland ETS ($46.10).

[39] Lichtenstein ($101.47), Sweden ($137.24) and Switzerland carbon tax ($101.47).

Figure 6: 2021 emissions prices by jurisdiction, USD per tonne



Source: World Bank, "Carbon Pricing Dashboard." OECD, "Carbon Pricing in Times of COVID-19"; International Carbon Action Partnership, "Allowance Price Explorer."

Note: Prices except for China and the UK ETS are as-of April 1, 2021. Prices for China and UK ETS are end-of-2021. Denmark, Finland, Iceland, Luxembourg, Mexico, and Norway have prices that differ by fuel; the plot shows the range between the minimum and maximum prices. Mexico has a pilot ETS which started in 2020, but prices are not available. The 2020 recommended carbon price range is from the High-Level Commission on Carbon Prices.

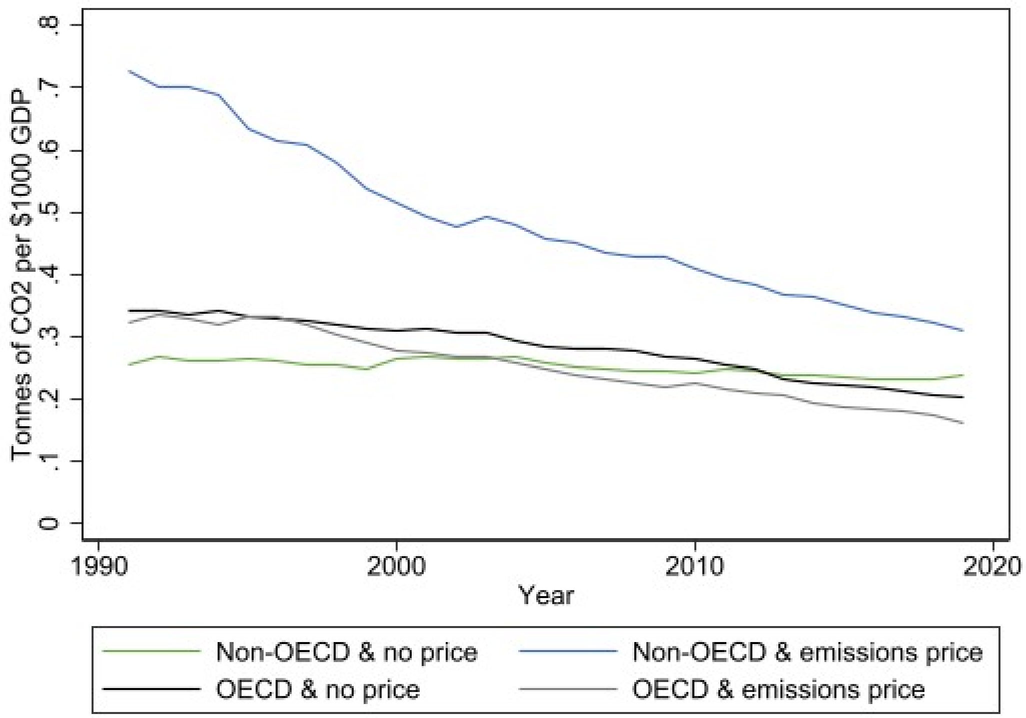
Emissions, emissions pricing, and trade

The vulnerability of a given country's economic activity to emissions pricing and emissions markets depends on the energy- and emissions-intensity of production, the price imposed on emissions, and the emissions embodied in trade. The emissions-intensity of production is generally decreasing (Figure 8), with the exception of non-OECD[40] countries that do not have emissions-pricing in place. OECD countries, not surprisingly, on average have a lower

[40] Organization for Economic Cooperation and Development, a proxy for developed countries.

CO_2-intensity of production. This means that, all else equal, imposing an emissions price is less costly for these countries.

Figure 7: Average CO_2 intensity of production, 1991 to 2019



Source: Hannah Ritchie and Max Roser, "CO_2 and Greenhouse Gas Emissions," *Our World in Data*, May 11, 2020, https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions.

Note: GDP is 2017 constant dollars, adjusted for purchasing power parity. Countries with an emissions price are classified as-of 2021. Within-group annual average presented.

Evidence on the severity of leakage is mixed, with the majority of work based on ex ante numerical simulations rather than ex post evaluation of emissions pricing.[41] These numerical simulations suggest leakage ranges from 5% to 30%, implying up to 30% of domestic emissions reductions are offset by increases in other jurisdictions.[42] Sector-specific analyses

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[41] For a review of the evidence, see Condon and Ignaciuk, "Border Carbon Adjustment and International Trade"; Frédéric Branger and Philippe Quirion, "Would Border Carbon Adjustments Prevent Carbon Leakage and Heavy Industry Competitiveness Losses? Insights from a Meta-Analysis of Recent Economic Studies," *Ecological Economics* 99 (March 1, 2014): 29–39, https://doi.org/10.1016/j.ecolecon.2013.12.010; Böhringer et al., "Potential Impacts and Challenges of Border Carbon Adjustments."

[42] Christoph Böhringer, Edward J. Balistreri, and Thomas F. Rutherford, "The Role of Border Carbon Adjustment in Unilateral Climate Policy: Overview of an Energy Modeling Forum Study (EMF 29)," *Energy Economics*, The Role of Border Carbon Adjustment in Unilateral Climate Policy: Results from EMF 29, 34

of emissions-intensive and trade-exposed industries suggest leakage is much higher, ranging from 20% to 70%.[43]

Evidence from direct ex post empirical analysis is also mixed. Analysis of the Kyoto Protocol suggests domestic emissions in committed countries decreases, but imported emissions and the emissions-intensity of imports increase.[44] Kanemoto et al. find emissions reductions by developed countries between 1990 and 2011 is more than offset by increases in embodied emissions in imports.[45] This suggests leakage is present and potentially significant. In contrast, evidence from EITE industries covered by the EU ETS suggests minimal or no leakage.[46] However, these results should be expected given low permit prices and free

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(December 1, 2012): S97–110, https://doi.org/10.1016/j.eneco.2012.10.003; Condon and Ignaciuk, "Border Carbon Adjustment and International Trade"; Branger and Quirion, "Would Border Carbon Adjustments Prevent Carbon Leakage and Heavy Industry Competitiveness Losses?"; Jared C. Carbone and Nicholas Rivers, "The Impacts of Unilateral Climate Policy on Competitiveness: Evidence From Computable General Equilibrium Models," *Review of Environmental Economics and Policy* 11, no. 1 (January 1, 2017): 24–42, https://doi.org/10.1093/reep/rew025.

[43] Damien Demailly and Philippe Quirion, "CO2 Abatement, Competitiveness and Leakage in the European Cement Industry under the EU ETS: Grandfathering versus Output-Based Allocation," *Climate Policy* 6, no. 1 (January 1, 2006): 93–113, https://doi.org/10.1080/14693062.2006.9685590; Jean Pierre Ponssard and Neil Walker, "EU Emissions Trading and the Cement Sector: A Spatial Competition Analysis," *Climate Policy* 8, no. 5 (January 1, 2008): 467–93, https://doi.org/10.3763/cpol.2007.0500; Meredith Fowlie and Mar Reguant, "Mitigating Emissions Leakage in Incomplete Carbon Markets," *Journal of the Association of Environmental and Resource Economists*, August 19, 2021, https://doi.org/10.1086/716765.

[44] Rahel Aichele and Gabriel Felbermayr, "Kyoto and the Carbon Footprint of Nations," *Journal of Environmental Economics and Management* 63, no. 3 (May 1, 2012): 336–54, https://doi.org/10.1016/j.jeem.2011.10.005; Rahel Aichele and Gabriel Felbermayr, "Kyoto and Carbon Leakage: An Empirical Analysis of the Carbon Content of Bilateral Trade," *The Review of Economics and Statistics* 97, no. 1 (2015): 104–15.

[45] K. Kanemoto et al., "International Trade Undermines National Emission Reduction Targets: New Evidence from Air Pollution," *Global Environmental Change* 24 (January 1, 2014): 52–59, https://doi.org/10.1016/j.gloenvcha.2013.09.008.

[46] Julia Renaud, "Climate Policy and Carbon Leakage – Analysis," IEA Information Paper (International Energy Agency, October 2008), https://www.iea.org/reports/climate-policy-and-carbon-leakage; Frédéric Branger, Philippe Quirion, and Julien Chevallier, "Carbon Leakage and Competitiveness of Cement and Steel Industries Under the EU ETS: Much Ado About Nothing," *The Energy Journal* 37, no. 3 (July 1, 2017), https://doi.org/10.5547/01956574.37.3.fbra; Sean Healy, Katja Schumacher, and Wolfgang Eichhammer, "Analysis of Carbon Leakage under Phase III of the EU Emissions Trading System: Trading Patterns in the Cement and Aluminium Sectors," *Energies* 11, no. 5 (May 2018): 1231, https://doi.org/10.3390/en11051231; Helene Naegele and Aleksandar Zaklan, "Does the EU ETS Cause Carbon Leakage in European Manufacturing?," *Journal of Environmental Economics and Management* 93 (January 1, 2019): 125–47, https://doi.org/10.1016/j.jeem.2018.11.004; Antoine Dechezleprêtre et al., "Searching for Carbon Leaks in Multinational Companies," *Journal of Environmental Economics and Management*, December 24, 2021, 102601, https://doi.org/10.1016/j.jeem.2021.102601.

allocations of permits to EITE industries. Moreover, leakage via economic relocation is generally thought to be a medium- to long-run phenomenon.[47]

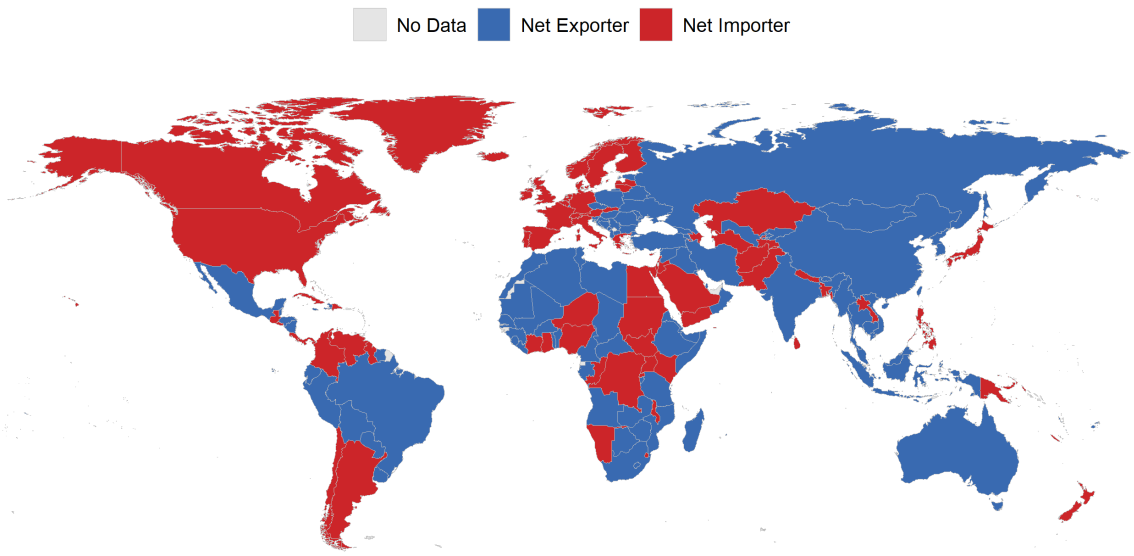
Nevertheless, as emissions pricing stringency increases, we can expect to see more concern about and evidence of leakage from unilateral action. Countries with emissions-intensive energy sources, and hence emissions-intensive production — like Canada and China — are relatively more vulnerable to emissions pricing. The remainder of this section explores emissions embodied in trade to identify countries more or less at risk of leakage, and then turns to the European Union's carbon border adjustment mechanism (CBAM) proposal as a case study of the complex interaction between trade and climate policy.

Trade in embodied emissions

Figure 9 presents the trade balance of GHG emissions embodied in trade in 2016, measured as net exports (imports less exports) of emissions. Net importers are those jurisdictions whose imported emissions embodied in consumption are greater than domestic production. Net exporters have domestic emissions that are greater than the embodied emissions in their imports. The data presented in the figure is consumption-based emissions, as opposed to production-based or territorial emissions. Consumption-based emissions accounts for total embodied emissions in final demand in each country, including the emissions from production along the entire supply chain. Under production-based accounting, the emissions from production of a good, such as a pen, are allocated to the sector and jurisdiction at each stage of the supply chain. For example, suppose the pen is bought in the UK, and manufactured in Spain using natural gas produced in Norway and plastics produced in Poland. With production-based accounting the emissions from natural gas production are allocated to Norway, the emissions from plastic production are allocated to Poland, the emissions from pen manufacturing are allocated to Spain, and the emissions from the shop in the UK are allocated to the UK. In contrast, under consumption-based accounting the sum of emissions through the value-chain are allocated to the UK. The benefit of consumption-based emissions is that it shows the true environmental damage from production, and is an indicator of emissions offshoring.

Figure 8: Trade balance of emissions, 2016

[47] Böhringer et al., "Potential Impacts and Challenges of Border Carbon Adjustments."



Source: KGM & Associated Pty Ltd, “The Eora Global Supply Chain Database,” n.d., https://worldmrio.com/.
Note: Trade balance is measured as net exports (imports less exports) of emissions. Positive values (red) indicate countries are net importers of CO_2, and negative values (blue) indicate net exporters. Some countries, such as Brazil and Canada, switch between net importers and net exporters of emissions.

There are four primary determinants of whether a country is a net importer or a net exporter of emissions. First, the emissions-intensity of a country’s energy system is a significant contributor to the emissions-intensity of production. Second, a country’s economic composition: the amount of economic activity from emissions-intensive sectors such as heavy industry, versus less-emission intensive activities such as services. Third, the amount of trade a country engages in. Fourth, the relative emissions-intensity of production of its trading partners. For example, a country with a low-emissions energy system and economic activity oriented towards services will have relatively low emissions intensity of domestic production. In contrast, a country with an emissions-intensive energy system and an economy focused on heavy industry such as refining or smelting will have a relatively high emissions-intensity of production. The former country is likely to be a net importer of emissions while the latter will be a net exporter.

Vulnerability to leakage, however, is more complex. It generally depends on the emissions-intensity of economic activity — how much an emissions price will affect production costs — and trade exposure — the amount of international competition and ability to pass costs on to consumers. A country could have an emissions-intensive sector such as steel smelting, but its trade exposure could be quite small, limiting this vulnerability. Interestingly, many jurisdictions designate electricity as EITE, despite its lack of trade exposure, because of the ubiquity of electricity as an input in other products.[48] While measuring competitiveness and vulnerability to leakage is challenging,[49] it is an important part of current emissions pricing mechanisms and for thinking about the terms-of-trade effects of emissions pricing. Net exporters are also exposed to potential effects of border carbon adjustments.

With some exceptions, the majority of developed countries are net importers of emissions. The fact that developed — rich — countries are net importers suggests that despite these countries' progress in reaching Kyoto and Paris climate commitments domestically, they are doing so via (partially) increasing their imports from other jurisdictions with greater emissions intensity of production. Also of note in Figure 9 is that the majority of countries with emissions pricing, particularly Europe, are net importers of emissions. With increasingly stringent emissions pricing in these jurisdictions, there is the potential for more emissions leakage from these countries.

Figure 10 shows the change in emissions trade-shares between 1990 and 2019 for countries with and without emissions pricing (panel A) and for OECD[50] and non-OECD countries (panel B). The number of net importers increased between 1990 and 2019, as did average net imports. Countries with emissions pricing present in 2021 had a larger increase in their trade shares, that is, they import more emissions compared to 1990. On average, countries without emissions pricing saw little change in the emissions embodied in trade. This pattern repeats for OECD countries. However, what is notable about both panels is that these changes are quite small. Despite increases in international trade overall, increases in trade in intermediate inputs, and the rise of developing countries such as China and India as major suppliers, the majority of countries plotted had very little change in the emissions embodied in their trade.

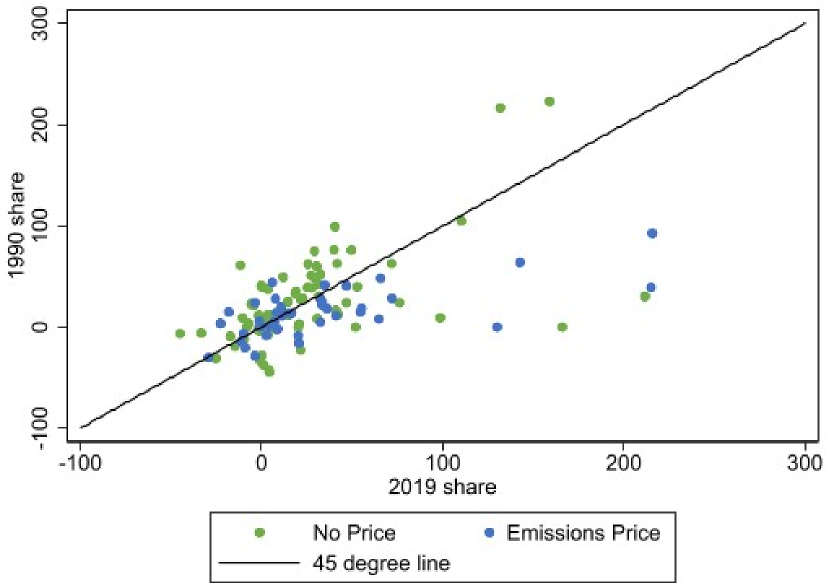
Figure 9: CO_2 emissions embodied in trade, 1990 vs 2019

[48] Dobson and Winter, "Assessing Policy Support for Emissions Intensive and Trade Exposed Industries."

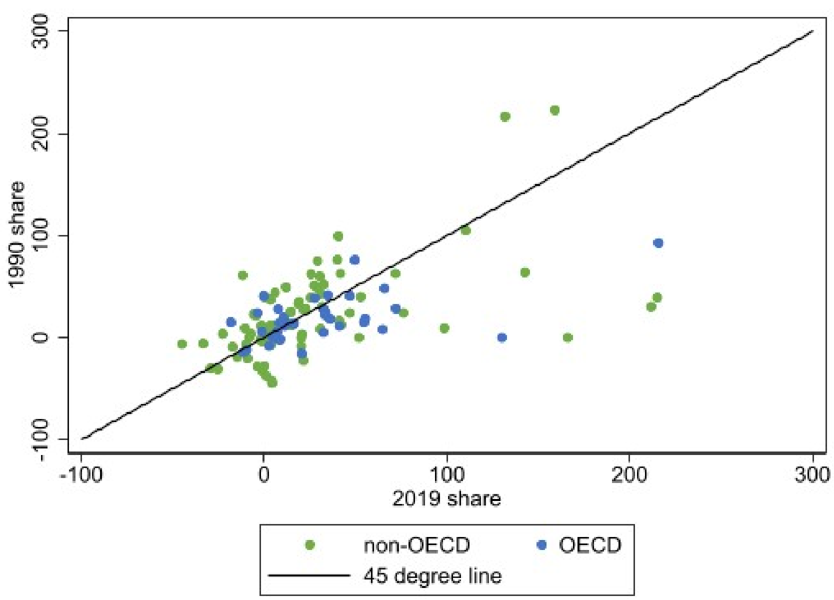
[49] Fowlie and Reguant, "Mitigating Emissions Leakage in Incomplete Carbon Markets"; Böhringer et al., "Potential Impacts and Challenges of Border Carbon Adjustments."

[50] Organization for Economic Cooperation and Development, a proxy for developed countries.

Panel A: Countries with and without emissions pricing



Panel B: OECD and non-OCED countries

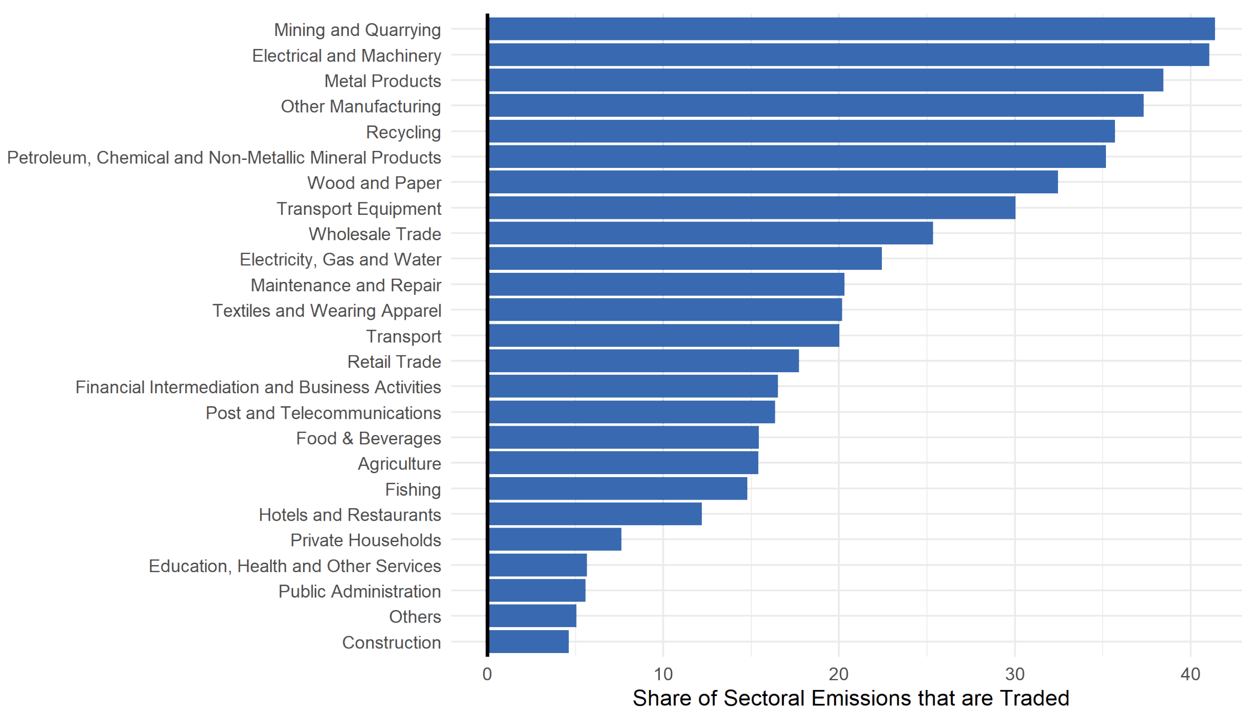


Source: Our World in Data, “CO□Emissions Embedded in Trade,” Our World in Data, accessed January 7, 2022, https://ourworldindata.org/grapher/share-co2-embedded-in-trade.

Note: N = 131. Emissions embodied in trade are measured as net exported and imported emissions (exports less imports) as a share of domestic emissions from production. Positive values indicate countries are net importers of CO_2, and negative values indicate net exporters. For example, a value of 10% means a country’s net imports of emissions are 10% of domestic emissions. The 45-degree line indicates where 1990 trade shares equal 2019 trade shares. Points above the line mean embodied emissions in 1990 are higher than in 2019.

While overall trade in emissions matters for the aggregate effects of domestic unilateral action, sector-specific emissions and the trade-exposure of sectors also influences leakage and leakage risk. Importantly, there is substantial variation in the share of emissions traded across sectors (Figure 11), measured by the share of a given sector's emissions that are exported. Not surprisingly, service-oriented sectors like hospitality and domestic-oriented sectors like construction have very little trade in emissions. In contrast, 12 sectors have over 20% of their emissions traded, and seven export over 30% of their emissions. The high share of traded emissions means emissions pricing affects these sectors relatively more, via greater exposure to international competition. A unilateral increase in price in one jurisdiction increases costs relative to all other countries and lessens the competitiveness of its exports in these sectors. The inability to pass costs through to importers prompts leakage risk for these industries.

Figure 10: Trade in emissions by sector, 2016



Source: KGM & Associated Pty Ltd, "The Eora Global Supply Chain Database."

Note: Shared of traded emissions measured by sectoral emissions exports as a share of total sectoral emissions.

Figure 11 also demonstrates that blanket economy-wide emissions pricing is not optimal when countries engage in unilateral emissions pricing. The low trade in emissions for some sectors mean that there is little risk of economic leakage, and therfore little need for industry supports such as output-based rebating or free permit allocations. Moreover, subsidising sectors with low trade exposure has two additional, negative effects. First, assuming a fixed budget for competitiveness supports, it relocates funding from sectors with leakage risk to those without, mitigating governments' ability to prevent leakage in trade-exposed sectors. Second, it unnecessarily undermines the price signal to end consumers, as discussed in Table 1. In practice, leakage mitigation policy is generally targeted, with jurisdictions going to significant effort to distinguish and define industries eligible for support.[51] For example, the EU ETS provides 100% of permit allocations for free to sectors deemed at the highest risk, and a maximum of 30% to less-exposed sectors.[52]

Importantly, there are also major differences in the emissions-intensity of production between OECD and non-OCED countries, including for specific economic sectors.[53] These industries include metals, non-metallic minerals, refined petroleum products, and chemical, rubber and plastic products. These sectors, which are both emissions-intensive and trade-exposed, have the greatest risk of leakage from developed countries with emissions pricing to developing countries without emissions pricing. Figure 12 presents leakage exposure by country, measured as traded emissions (imports plus exports) as a share of domestic production emissions. Of note is the high leakage exposure faced by developed countries with emissions pricing: Canada, European Union countries, Iceland, Norway, the United Kingdom, and Japan. Europe's leakage exposure is particularly stark, and provides additional context for the CBAM proposal, which we turn to next.

Figure 11: Leakage exposure by country, 2016

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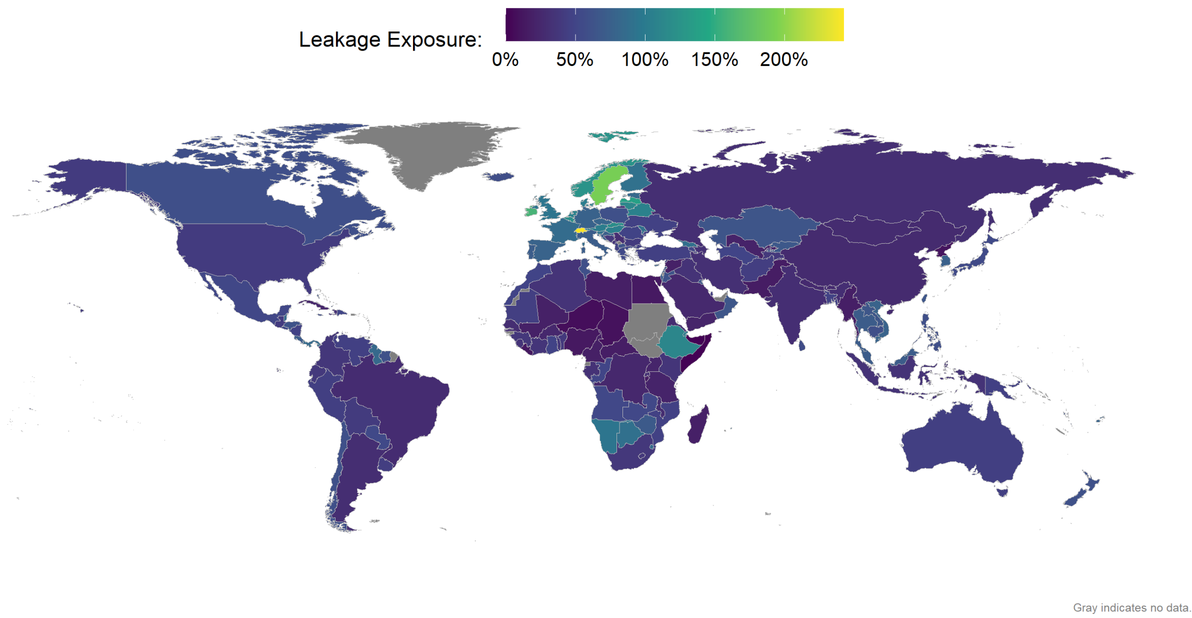
[51] Dobson and Winter, "Assessing Policy Support for Emissions Intensive and Trade Exposed Industries."

[52] European Commission, "Commission Delegated Decision (EU) 2019/708 of 15 February 2019 Supplementing Directive 2003/87/EC of the European Parliament and of the Council Concerning the Determination of Sectors and Subsectors Deemed at Risk of Carbon Leakage for the Period 2021 to 2030," Pub. L. No. 2019/708 (2019), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AL%3A2019%3A120%3AFULL; European Commission, "Allocation to Industrial Installations," accessed January 11, 2022, https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/free-allocation/allocation-industrial-installations_en.

[53] Böhringer et al., "Potential Impacts and Challenges of Border Carbon Adjustments."



Source: KGM & Associated Pty Ltd.

Note: Leakage exposure measured by emissions' imports plus exports as a share of domestic production emissions. Gray indicates no data.

The European Commission CBAM proposal

The European Commission published its regulatory proposal for a carbon border adjustment mechanism in July 2021, and is a major pillar of the Fit for 55 climate plan. Fit for 55 is a package of 13 policies and policy proposals to reduce EU emissions to 55% (or more) below 1990 levels by 2030 and meet the objectives of the European Green Deal.[54] Both the 2030 target and net zero emissions by 2050 became legally binding on July 29, 2021.[55] The CBAM and ETS-amendment proposals will change EU emissions-pricing policy in several important ways. First, extending the ETS to maritime transport and potentially extending the ETS to international aviation.[56] Second, creating a separate ETS for road transportation and

[54] European Commission Secretariat General, "Communication from the Commission: The European Green Deal," Communication (Brussels: European Commission, December 11, 2019), https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF; European Council, "Fit for 55," December 22, 2021, https://www.consilium.europa.eu/en/policies/green-deal/eu-plan-for-a-green-transition/.

[55] European Commission, "European Climate Law," Climate Action, accessed January 12, 2022, https://ec.europa.eu/clima/eu-action/european-green-deal/european-climate-law_en.

[56] Press Office - General Secretariat of the Council, "Environment Council Background Brief" (European Council, December 20, 2021), https://www.consilium.europa.eu/media/53399/background-brief-environment-council-20211220.pdf.

buildings' emissions.[57] Third, and most important from a policy design and policy change perspective, introducing a carbon border adjustment mechanism on cement, iron and steel, aluminum, fertilisers, and electricity, and phasing out free allocation of emissions permits for those sectors.[58] The five sectors identified in the CBAM proposal accounted for 55% of industrial emissions and 40% of total EU emissions in 2020.[59] These sectors have a high amount of embodied emissions in trade (Figure 11, above) and were identified for the CBAM based on their overall emissions and trade exposure.[60] The supporting emissions-reporting system for countries exporting to the EU is proposed to apply by 2023, with the CBAM's financial adjustment in place in 2026.[61] The CBAM adjustment requires exporters to the EU to purchase CBAM certificates at the prevailing price for ETS allowances.

The rationale for the CBAM is to "ensure the price of imports reflects more accurately their carbon content" whilst addressing leakage and strengthening the emissions price signal present in the ETS.[62] The proposal explicitly raises the issue of free allocations of emissions permits lowering average costs for ETS-covered facilities and the accompanying decreased incentive to invest in additional GHG mitigation. The proposed CBAM would apply to non-EU countries, though countries participating in the EU ETS or with an ETS linked to the EU ETS would be exempt — this would apply to Iceland, Liechtenstein and Norway, as members of the EU ETS, and Switzerland with a linked ETS.[63] The CBAM would initially only price direct production emissions, though the proposal includes an intention to expand the scope to indirect emissions in the future. Imports from countries that have emissions pricing in place

[57] European Council, "Fit for 55."

[58] European Commission, "Carbon Border Adjustment Mechanism: Questions and Answers."

[59] European Commission, "Commission Staff Working Document Impact Assessment Report Accompanying the Document Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism," Staff Working Document (European Commission, July 14, 2021), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021SC0643.

[60] European Commission, "Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism" (Brussels: European Commission, July 14, 2021), https://eur-lex.europa.eu/resource.html?uri=cellar:a95a4441-e558-11eb-a1a5-01aa75ed71a1.0001.02/DOC_1&format=PDF.

[61] European Commission, "Carbon Border Adjustment Mechanism: Questions and Answers."

[62] European Commission, "Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism," 3.

[63] European Commission, "Carbon Border Adjustment Mechanism: Questions and Answers."

would have those costs deducted from the CBAM price. The proposal does not include a provision for export rebates for EU production.

There are six major conceptual and practical challenges associated with the CBAM's implementation. First is the issue of emissions leakage. The current proposal provides incomplete adjustment for leakage compared to the EU ETS with free permit allocations for industries designated as emissions-intensive and trade-exposed. The CBAM will equalize within-EU emissions prices, providing domestic producers protection from imports from countries with less-stringent environmental policies. However, because there is no proposed adjustment to EU exports, the CBAM does not protect producers' international competitiveness. Given that EU countries are net importers of emissions (Figure 9), this may be less of a concern. Moreover, it is possible that export rebates would be inconsistent with WTO rules, as they would increase emissions and undermine the consistent treatment of domestic and non-domestic firms.[64] However, incomplete leakage protection may pose an obstacle to implementation.

Second, and related, is treatment of indirect emissions, the emissions embodied in trade and the intermediate inputs to production of final goods covered by the CBAM. The 2021 proposal states the CBAM will only apply to direct emissions, but articulates a desire to expand it to indirect emissions, an opinion shared by the European Parliament's Committee on International Trade.[65] The initial sectors to be covered by the CBAM have a high share of traded emissions, and so including only direct emissions will mean a proportion of emissions embodied in production will remain unpriced. Think of a good with its supply chain entirely within the EU — the presence of the ETS and country-specific supplementary emissions pricing instruments means the majority of embodied emissions face a price. Now compare this to an imported (identical) good, where only the direct emissions are priced via a CBAM adjustment. While only accounting for direct emissions in the CBAM adjustment is simpler, it does present a competitiveness issue. However, calculating the indirect emissions is a

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64 Böhringer et al., "Potential Impacts and Challenges of Border Carbon Adjustments."

65 European Parliament Committee on International Trade, "Draft Opinion of the Committee on International Trade for the Committee on Environment, Public Health and Food Safety on the Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism" (European Parliament, November 22, 2021), https://www.europarl.europa.eu/doceo/document/INTA-PA-699250_EN.pdf.

non-trivial exercise, and requires detailed information about the emissions at each stage of production and by jurisdiction. There is increasingly available high-quality data to support these calculations[66], but there is also a trade-off between accuracy and specificity in embodied emissions calculations and administrative complexity. As the majority of emissions embodied in many EITE goods are indirect,[67] this will likely become increasingly important in policy design going forward. Including indirect emissions also requires revisiting the issue of burden-sharing, as indirect emissions are higher for EITE sectors in less-developed, non-OECD countries.[68]

Third, and following from the second issue, is calculating the adjustment factor. Once the scope of emissions covered by CBAM is set, the question becomes how to manage the trade-off between administrative complexity and specificity in emissions benchmarks (default emissions metrics) for covered sectors. Implementing the CBAM requires determining the quantity of direct emissions in imports — a benchmark — in order to price them. One option to minimize administrative complexity is to assign product-specific benchmarks, which could be based on a technology standard or the average emissions intensity of global production. A major challenge with this approach is that it provides no incentives to exporting firms to lower their emissions intensity — they face the same CBAM adjustment regardless of production processes. A firm-specific verification process would alleviate this concern, and is included in the 2021 proposal, but again increases administrative complexity. Relatedly, the weakness or strength of the benchmark matters — a weak benchmark creates little incentive for emissions reductions by exporters to the EU, whereas a strong benchmark could be considered unfairly punitive and create pressure for exemptions.[69] Another consideration is whether production processes for goods should matter in choosing benchmarks. For example, direct emissions from steel production using hydrogen are lower than traditional methods that rely on coal. However, differential treatment by production

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[66] There are numerous datasets that account for embodied emissions in trade, such as databases from the Global Trade Analysis Project and the Eora Global Supply Chain Database. However, these databases tend to lag by several years and rely on assumptions to fill in missing information, which may not be practical or feasible to rely on for policy implementation.

[67] Böhringer et al., “Potential Impacts and Challenges of Border Carbon Adjustments.”

[68] Böhringer et al.

[69] Cosbey et al., “Developing Guidance for Implementing Border Carbon Adjustments.”

process must be compliant with international trade law, which requires equivalent treatment for domestic production within the EU, and may prevent more detailed adjustments.[70]

The CBAM proposal suggests an adjustment based on actual emissions, with default standards in the case of missing information, and an opportunity for firms to demonstrate performance relative to the default. The proposed default standards are the average emissions intensity of production for product-country pairs, and when data is absent, the average emissions intensity of the bottom 10% of EU facilities producing that good. For electricity, the default standard without country of origin data is the EU weighted-average of fossil-fuel electricity production. The CBAM proposal is clearly trying to thread the needle of limiting administrative complexity by setting emissions intensity at the exporting country's average for a product, and incentivizing emissions reductions in third countries by allowing for an adjustment where firms can demonstrate lower emissions intensity. However, the proposed benchmarks appear relatively weak, and so are unlikely to incentivize significant emissions reductions outside the EU in the short term.

The fourth important design element is potential adjustments by country (which may be difficult to calculate or verify). There are two main reasons for this: one, to allow for differential treatment of developing countries (DCs) and least-developed countries (LDCs), and two, to account for emissions pricing in a country of origin. The CBAM proposal is entirely silent on any potential differential treatment of DCs or LDCs, beyond promising technical assistance for compliance.[71] There is a long history of preferential trade treatment of developing countries and LDCs by industrialized countries under the Generalized System of Preferences, to support their economic development via limiting trade barriers.[72] Given the higher emissions-intensity of production in less-developed countries compared to European Union nations, blanket application of the CBAM risks shifting the burden of emissions

[70] Cosbey et al.

[71] The accompanying impact assessment report does discuss potential impacts and mitigation options. See European Commission, "Commission Staff Working Document Impact Assessment Report Accompanying the Document Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism."

[72] Steven Klasen et al., "Trade Preferences for Least Developed Countries. Are They Effective? Preliminary Econometric Evidence," CDP Policy Review (United Nations Committee for Policy Development, October 2016), https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/CDP-review-2016-4.pdf.

reductions to developing countries.[73] Failure to address this issue in policy design is inconsistent with the principles of Article 2 of the Paris Agreement. The counter-argument is that a blanket exemption would limit the emissions-reduction incentive in these countries and undermine the leakage-prevention inherent in the CBAM, as well as country-based exemptions could unfairly discriminate amongst the EU's trading partners.[74] To maintain alignment with the Paris Agreement and international trade law, the CBAM design will likely need to be amended to address developing countries' concerns, despite the expected economic and environmental inefficiencies. Use of CBAM revenues to assist developing countries could also address this issue.

On county-of-origin emissions pricing, Article 9 of the CBAM proposal allows for reducing the CBAM adjustment when "the declared embedded emissions were subject to a carbon price in the country of origin of the goods" and are not "subject to an export rebate or any other form of compensation on exportation."[75] However, the proposal does not define what an export rebate is, and this will need to be rectified in policy design. This issue is particularly important as many countries with emissions pricing also have competitiveness adjustments embodied in their systems. It remains unclear how free allocations of permits or output-based rebating will be treated by the CBAM, as these are not export-specific competitiveness adjustments in countries of origin. In this instance, whether the average cost of emissions or the marginal cost of emissions is used to adjust the CBAM price will be paramount. If average cost is used, then the CBAM may accelerate the phase-out of competitiveness measures in other countries; if marginal cost is used, there will be less pressure. One additional benefit of the adjustment for emissions pricing outside the EU is it could prompt third countries to adopt emissions pricing or improve stringency where there is a price differential. In time, this would create greater coherence and alignment in global climate policy. Of note, however, is that this approach also has negative connotations. It excludes non-price actions to reduce

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[73] Cosbey et al., "Developing Guidance for Implementing Border Carbon Adjustments"; Böhringer et al., "Potential Impacts and Challenges of Border Carbon Adjustments."

[74] Cosbey et al., "Developing Guidance for Implementing Border Carbon Adjustments"; European Commission, "Commission Staff Working Document Impact Assessment Report Accompanying the Document Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism."

[75] European Commission, "Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism," 32.

emissions, which, while generally more costly per tonne than market-based approaches, are a legitimate approach to emissions mitigation that would be unvalued under a CBAM. Second, it imposes the EU's assessment of the "appropriate" emissions price on other national actors, which could cause tensions beyond those present in the CBAM's design and treatment of third countries.

The fifth challenge with the CBAM's long-term implementation is total coverage. The proposal leaves open the option to expand the CBAM to sectors beyond the initial five, and some EU bodies argue it would ideally apply to "all emissions covered by the EU ETS."[76] However, narrow coverage is likely more beneficial than broad. First, leakage differs by sector, and the most benefits from leakage-prevention policy come from targeted support to sectors with the highest leakage risk.[77] Second, the administrative complexity of applying the CBAM to all sectors, particularly those with low leakage risk, creates costs that are large relative to the benefits from avoided leakage. Third, blanket application of the CBAM would likely be considered protectionist and strains the credibility of the policy as an environmental action. Finally, increasing the number of products that are covered by a CBAM increases the burden of emissions-reductions on developing countries, and is unlikely to reduce the overall cost of reducing global emissions.[78]

The final and sixth issue is the mechanism for setting the CBAM certificate price. In tying the CBAM adjustment to the EU ETS price, there is automatic uncertainty for exporters to the EU regarding the cost they face. This occurs because the ETS sets the quantity of allowable emissions in a given year, and permit auctions determine the price of emissions permits. While the cap and trade system generates certainty about the quantity of emissions, prices are a function of firms' demand for permits, which depends on their output, investments in abatement technologies, and the amount of free allocation of permits, amongst other factors.

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[76] European Parliament Committee on International Trade, "Draft Opinion of the Committee on International Trade for the Committee on Environment, Public Health and Food Safety on the Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism," 4/42.

[77] Christoph Böhringer, Jared C. Carbone, and Thomas F. Rutherford, "Unilateral Climate Policy Design: Efficiency and Equity Implications of Alternative Instruments to Reduce Carbon Leakage," *Energy Economics*, The Role of Border Carbon Adjustment in Unilateral Climate Policy: Results from EMF 29, 34 (December 1, 2012): S208–17, https://doi.org/10.1016/j.eneco.2012.09.011.

[78] Christoph Böhringer, Jared C. Carbone, and Thomas F. Rutherford, "Embodied Carbon Tariffs," *The Scandinavian Journal of Economics* 120, no. 1 (2018): 183–210, https://doi.org/10.1111/sjoe.12211.

Tying the CBAM certificate price to the EU ETS price ensures equal treatment of domestic and imported products, but means exporters to the EU will not know with certainty the border adjustment they face, creating additional complexity in trade relationships. The uncertainty is not unique to exporters, as EU ETS participants also have price uncertainty, but it may be of greater concern to exporters to the EU. This may need to be addressed as part of the transition to the CBAM, via maximum and minimum bounds on the CBAM certificate price or some other policy mechanism.

Summary and conclusions

Trade matters for climate policy. The effectiveness of unilateral action to mitigate domestic emissions is undermined by international trade, as differential climate policy across jurisdictions combined with trade in goods, services and capital can cause emissions leakage. There are vast differences in prices and coverage across countries, which contributes to leakage risk. To date, prices have been low, mitigating the risk of leakage but this is unlikely to remain the status quo.

In the coming years, parties to the Paris Agreement will design and implement increasingly stringent domestic policy to meet their ambitious emissions-reduction goals for 2030 and mid-century. Moreover, the most ambition comes from developed countries, which are generally net importers of emissions and have high leakage exposure from their trade.

Numerous countries are rethinking their emissions pricing policies, with the two goals of minimizing emissions leakage and incentivizing climate action elsewhere. The most prominent example related to international trade is the European Union's proposal for a carbon border adjustment mechanism. More complex than domestic leakage-mitigation policy, the CBAM's design will be crucial for shaping international climate policy in the years ahead. This is particularly true for other countries considering BCAs but without a firm policy proposal. The EU CBAM's implementation could lead to greater policy coherence and price alignment globally, or less cooperation and higher-cost emissions reductions overall. Treatment of other nations' emissions-pricing and treatment of less-developed countries are key factors related to international trade that will determine its success.

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